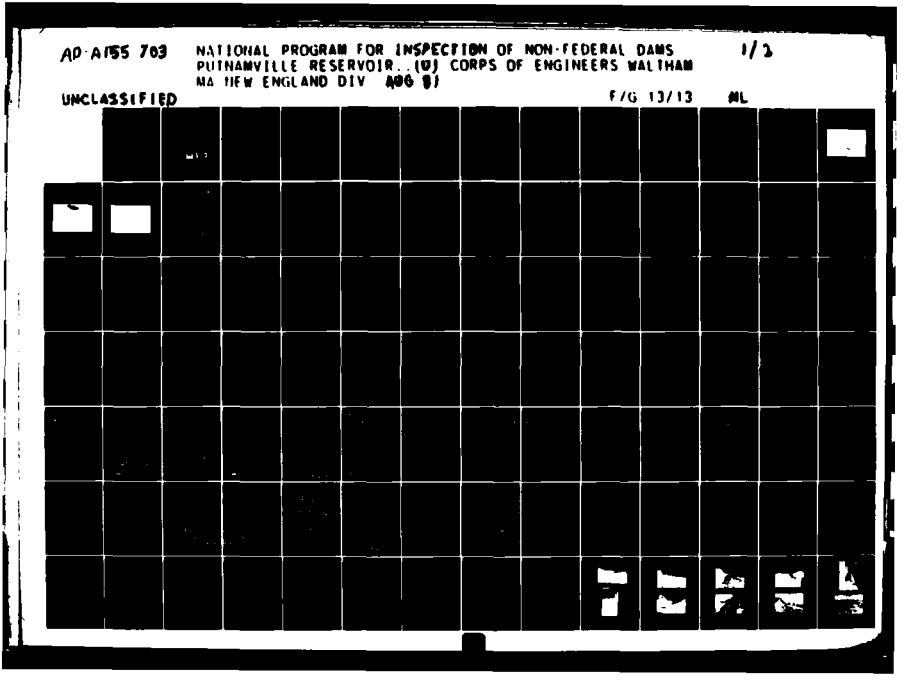
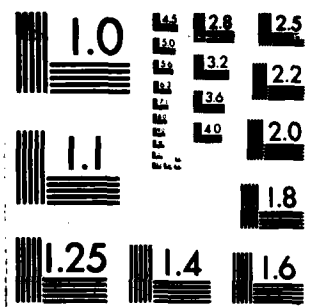
AD-A155 703 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS PUTNAMVILLE RESERVOIR..(U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV AUG 81 1/2

UNCLASSIFIED F/G 13/13 NL





IPSWICH RIVER BASIN
DANVERS, MASSACHUSETTS

PUTNAMVILLE RESERVOIR DAM & DIKES

DAM
MA 00745

EAST DIKE
MA 01297

WEST DIKE
MA 00744

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1981

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MA 00745/01297/00744	2. GOVT ACCESSION NO. AD-A156703	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Petnamville Reservoir Dam and Dikes NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		12. REPORT DATE August 1981 13. NUMBER OF PAGES 145
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,
pswich River Basin
Danvers Massachusetts
Tributaries of the Ipswich River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The reservoir is impounded by a 1400 ft. long dam, a 2100 ft. long dike in the east side and by a 700 ft. long dike on the west side. There are no operating facilities at the dikes. There are deificiencies that must be corrected to assure the continued performance of the dam and dikes. Generally the dam ans dikes are in fair condition. It is recommended that the owner employ a qualified engineer to conduct various studies of the dam and dikes.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

REPRODUCED AT GOVERNMENT EXPENSE

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

PUTNAMVILLE RESERVOIR DAM AND DIKES

DAM MA00745
EAST DIKE MA01297
WEST DIKE MA00744

IPSWICH RIVER BASIN
DANVERS, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION
PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
BRIEF ASSESSMENT

Identification No.: MA00745
MA01297
MA00744

Name of Dam: Putnamville Reservoir Dam
Putnamville Reservoir East Dike
Putnamville Reservoir West Dike

Town: Danvers

County and State: Essex County, Massachusetts

Stream: Tributaries of the Ipswich River

Date of Inspection: June 16-17, 1981

Putnamville Reservoir was built in 1954 and is a pumped storage reservoir used for water supply. The reservoir is impounded by a 1,400-foot long dam, a 2,100-foot long dike on the east side and by a 700-foot long dike on the west side. Each of these structures is a zoned earthfill embankment with a reinforced concrete parapet at the top of the upstream slope. The parapets were added in 1978 when the elevation of the top of the reservoir was increased by 5 feet. A 360-foot long earthfill dike is also located on the south side of the reservoir.

Putnamville Reservoir Dam has a maximum height of 37.4 feet with the top at Elevation (El) 83.8 National Geodetic Vertical Datum (NGVD). The dam has a maximum storage capacity of 8,300 acre-feet and is of intermediate size. The spillway is a 30-foot long, modified ogee weir with the crest at El 79.8. Discharge flows into a concrete channel that leads to a concrete stilling basin and a rockfill auxiliary stilling basin. The outlet is a 3-foot diameter prestressed concrete cylinder pipe that is also used to fill and drain the reservoir. Three intakes that connect to the pipe are located in a gatehouse on top of the dam. The lowest intake is a 3-foot diameter prestressed concrete cylinder pipe with an invert at El 45.4. It is controlled by a manually-operated valve in the gatehouse.

Putnamville Reservoir East Dike has a maximum height of 23.6 feet with the top at El 83.9. The West Dike has a maximum height of 26.1 feet with the top at El 84.2. The South Dike is 5 feet high and the top is at El 83.8. There are no operating facilities at the dikes.

There are deficiencies that must be corrected to assure the continued performance of the dam and dikes. This conclusion is based on a visual inspection of the sites and a review of the available data. Generally, the dam and dikes are in fair condition.

The same deficiencies were observed at the dam, east dike, and west dike. These deficiencies are: seepage along the downstream toe, a dense growth of brush and trees at the toe and in the downstream areas, inadequate riprap in areas along the top of the upstream slope, and animal burrows on the downstream slope. At the dam, additional deficiencies are the accumulation of rocks and debris in the spillway channel and stilling basin; and the inadequate capacity of the low-level outlet. The only deficiency at the south dike is inadequate riprap on the upstream slope.

Based on Corps of Engineers' guidelines, the dam, east dike, and west dike are classified in the high hazard category. The south dike is classified in the low hazard category. A test flood equal to the full probable maximum flood (PMF) was used to evaluate the capacity of the spillway. The test flood outflow is 462 cfs, resulting in a reservoir level at El 82.3. The test flood would not overtop the dam or the dikes. Hydraulic analyses indicate that the spillway can discharge 960 cfs, or 208 percent of the test flood outflow before overtopping would occur.

It is recommended that the Owner employ a qualified registered professional engineer to conduct the following studies for the dam, east dike, and west dike: install and monitor a system for measuring the seepage through the embankments; design a system to drain water away from the downstream toe; develop procedures for clearing vegetation downstream; design adequate riprap for the upstream slope; further investigate animal burrows on the downstream slope; and conduct a seismic stability analysis of the embankment. For the south dike, the Engineer should design adequate riprap for the upstream slope. The Engineer should also conduct further hydraulic studies to increase the discharge capacity of the low-level outlet.

The Owner should repair the deficiencies listed above, as described in Section 7.3. The Owner should also implement a program of annual technical inspections, a plan for surveillance of the dam and dikes during and after periods of heavy rainfall, and a plan for notifying downstream residents in the event of an emergency at the dam, east dike, or west dike.

The measures outlined above and in Section 7 should be implemented by the Owner within a period of one year after receipt of this Phase I Inspection Report.

Edward M. Greco, P.E.
Project Manager
Metcalf & Eddy, Inc.

Massachusetts Registration
No. 29800

Approved by:

Stephen L. Bishop, P.E.
Vice President
Metcalf & Eddy, Inc.

Massachusetts Registration
No. 19703

This Phase I Inspection Report on Putnamville Reservoir Dam and Dikes has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

RICHARD J. DIBUONO, Member
Water Control Branch
Engineering Division

ARAMAST MAHTESIAN, Member
Geotechnical Engineering Branch
Engineering Division

CARNEY TERZIAN, Member
Design Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions will be detected.

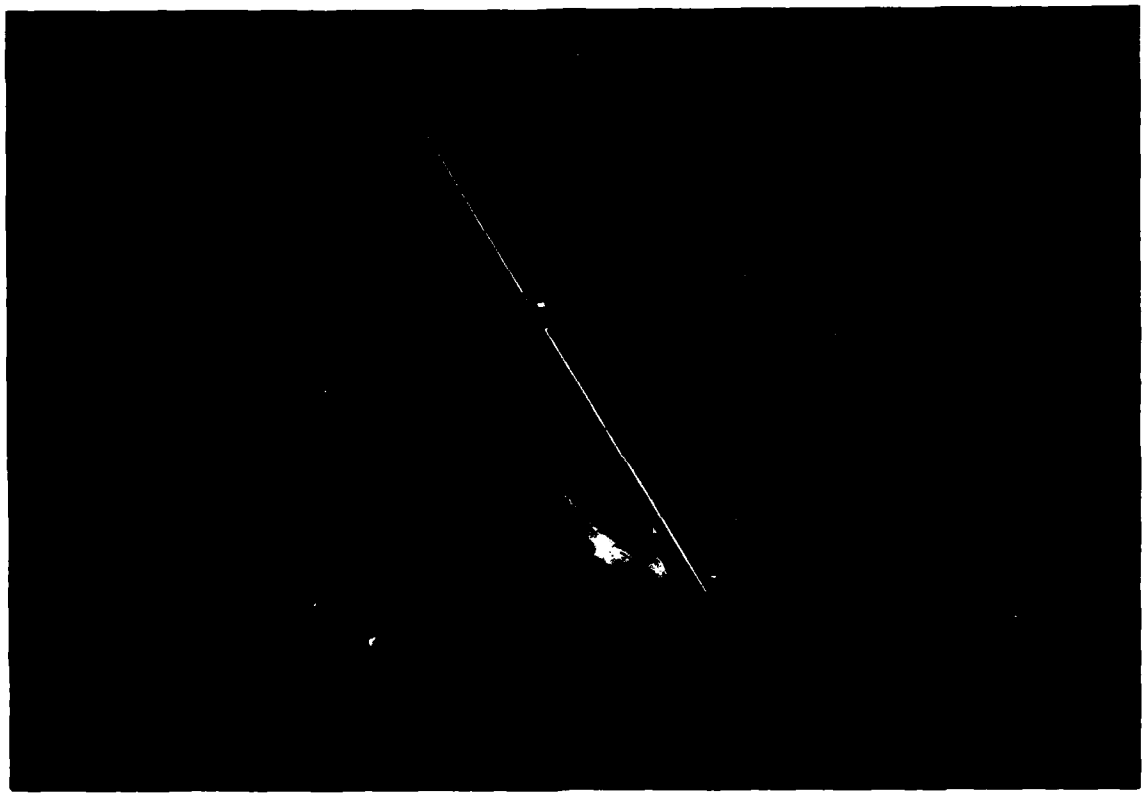
Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general conditions and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

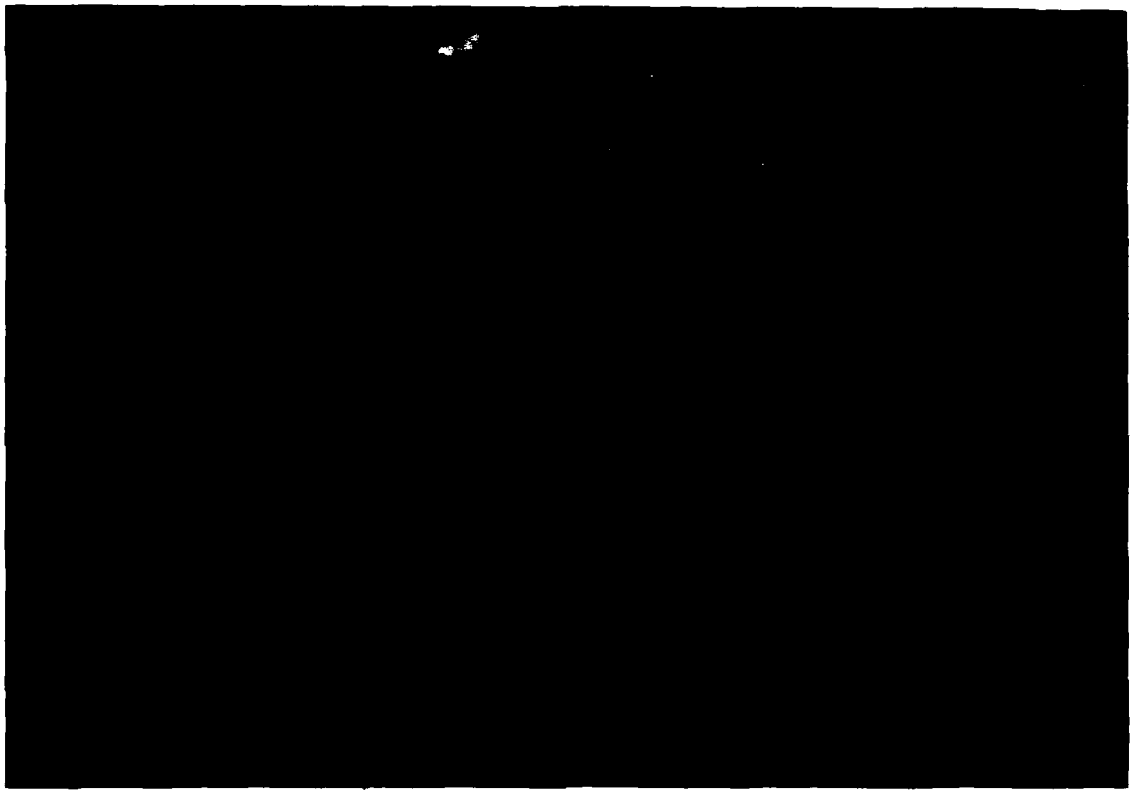
TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

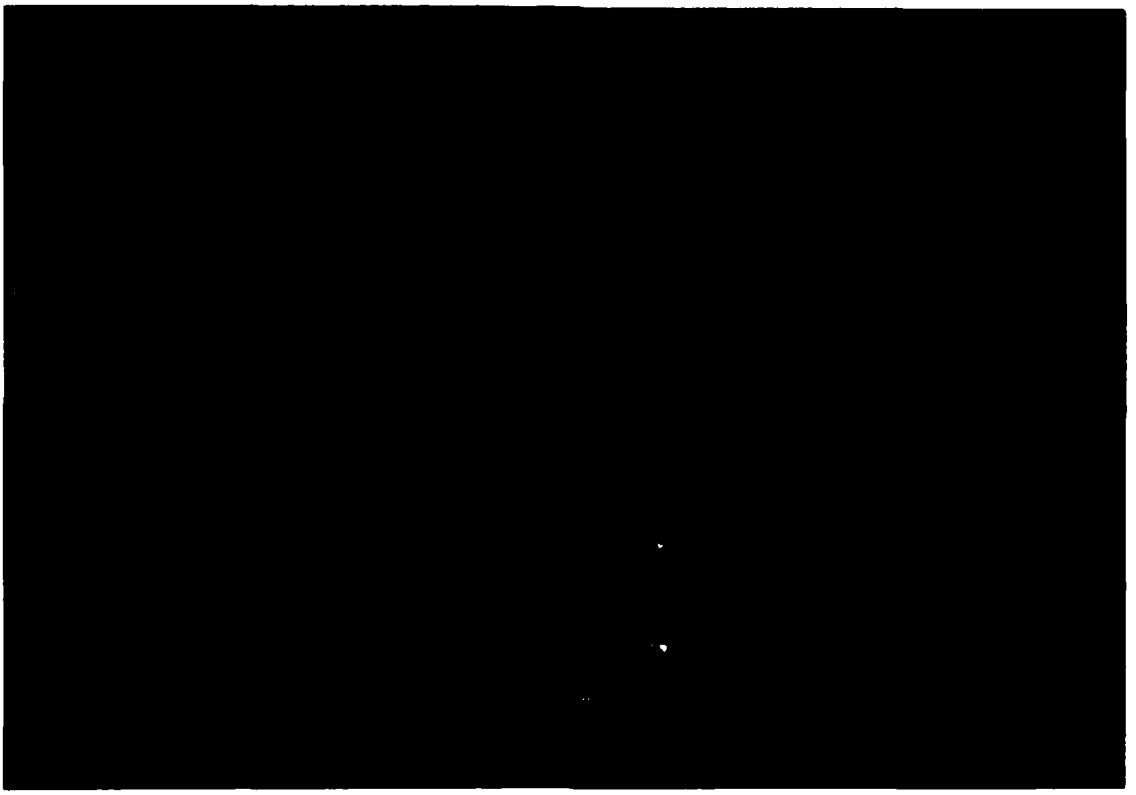
OVERVIEW
PUTNAMVILLE RESERVOIR DAM
DANVERS, MASSACHUSETTS

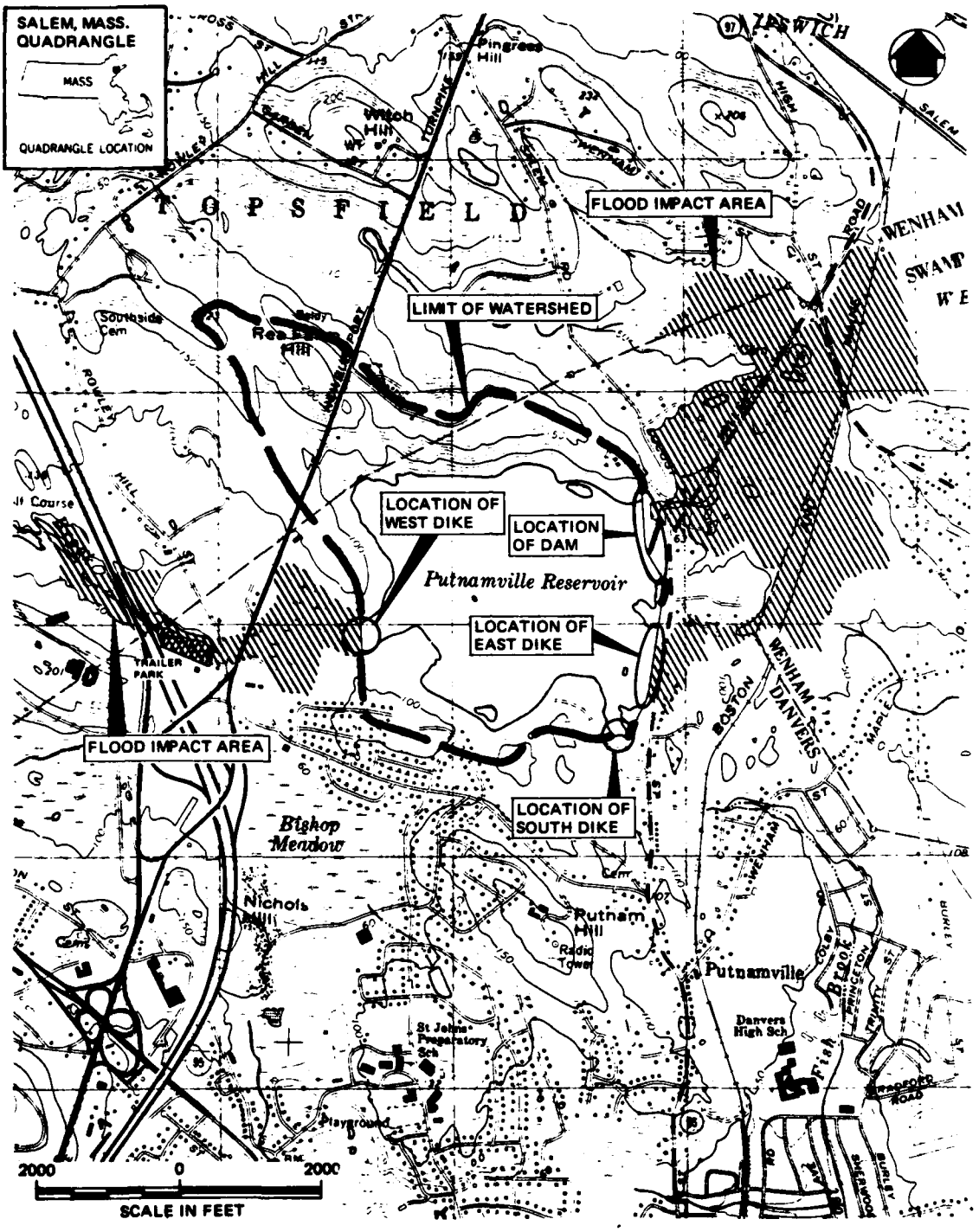


OVERVIEW
PUTNAMVILLE RESERVOIR EAST DIKE
DANVERS, MASSACHUSETTS



OVERVIEW
PUTNAMVILLE RESERVOIR WEST DIKE
DANVERS, MASSACHUSETTS





LOCATION MAP – PUTNAMVILLE RESERVOIR DAM AND DIKES

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

PUTNAMVILLE RESERVOIR DAM AND DIKES

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Metcalf & Eddy, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Contract No. DACW 33-80-C-0054, dated April 18, 1980, has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and assist the States to quickly initiate effective dam safety programs for non-Federal dams.

(3) Update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. The dam and dikes are located in the Ipswich River Basin the Town of Danvers, Essex County, Massachusetts (see Location Map). The dam is on an unnamed brook that joins the Ipswich River 1.7 miles downstream. There is no stream at the east dike or at the south dike. The west dike is on Nichols Brook that joins the Ipswich River 2.6 miles downstream. The coordinates of the embankment locations are the following:

	Latitude (north)	Longitude (west)
Dam	42 deg. 36.3 min.	70 deg. 56.5 min.
East Dike	42 deg. 36.0 min.	70 deg. 56.4 min.
West Dike	42 deg. 36.1 min.	70 deg. 57.3 min.
South Dike	42 deg. 35.7 min.	70 deg. 56.5 min.

Putnamville Reservoir Dam is a 1,400-foot long, earthfill dam with a maximum height of 37.4 feet (see Plan of Dam and Sections in Appendix B and photographs in Appendix C). A reinforced concrete parapet at the top of the upstream slope extends about 3 feet above the earth embankment. The wall is 1 foot wide and the top varies from El 83.8 to 83.9. The top of the embankment is 12 feet wide and varies from El 80.2 to 81.4. The upstream face is a 2.5:1 (horizontal:vertical) slope covered with riprap. The downstream face is a 2:1 slope covered with grass and weeds. A bench 6 feet wide is located near the bottom of the downstream slope north of the spillway. The bench contains a paved gutter that directs runoff toward the north abutment (see Figure B-2). Available drawings indicate that the dam is a zoned embankment consisting mostly of impervious fill (see Figure B-2). Pervious fill is located under the downstream slope and along the base of the embankment on the downstream side. The pervious layers connect to a rockfill drain along the downstream toe. The drawings also show that the dam is founded on glacial till and bedrock with a cutoff trench up to 15 feet below the base of the dam.

A concrete spillway and discharge channel are located 475 feet north of the south abutment of the dam. Vertical retaining walls form the approach channel of the spillway. The crest is a 30-foot long, modified ogee weir at El 79.8. There are no gates, stoplogs, or flashboards on the crest. Downstream, the discharge channel is 130 feet long and 8.5 feet wide at the bottom. The sidewalls are 4.5 to 6 feet high and are battered slightly outward. A concrete stilling basin extends 50 feet downstream of the discharge channel. An auxiliary stilling basin filled with large-size riprap is located immediately downstream of the concrete stilling basin. Underdrains 4 to 6 inches in diameter are located beneath the discharge channel and stilling basin. These drains discharge into the stilling basin and auxiliary stilling basin, respectively.

Putnamville Reservoir is operated as a pumped-storage reservoir for water supply purposes. Water is pumped from the Ipswich River into the reservoir and is later released into Wenham Lake, about 2 miles east of the dam. A 3-foot diameter prestressed concrete cylinder pipe carries water into and out of the reservoir. This pipe would be the only means of lowering the reservoir in an emergency. Three intakes connect to the pipe inside of a gatehouse located on top of the dam (see Figure B-9). The intakes are prestressed concrete cylinder pipes extending from the upstream face of the dam. The lower and middle intakes are 3 feet in diameter with inverts at El 45.4 and El 54.7. The upper intake is 2.5 feet in diameter with the invert at El 70.0. Manually operated gate valves control flow through the intakes.

The east dike is a 2,100-foot long earthfill embankment immediately south of the dam and separated from it by a small knoll. The maximum height of the east dike is 23.6 feet. The top is a concrete parapet wall similar to that on the dam and varies from El 83.9 to 84.1. The top of the earth embankment varies from El 80.2 to El 81.3 and is covered with grass and weeds. The upstream face is a 2.5:1 slope covered with riprap, and the downstream slope is 2:1 covered with grass. Available drawings show that the dike is a zoned earthfill embankment constructed in the same way as the dam. However, the drawings indicate that the east dike is founded entirely on granite bedrock, with the impervious cutoff trench extending only to the top of bedrock. A system of ditches and pipes was constructed downstream of the east dike to drain flow from the toe drain and from surface runoff that collects in low areas. These pipes extend under Locust Street and discharge into Wenham Swamp about 1,500 feet to the east. There is no spillway or outlet at the east dike.

The west dike is a 700-foot long embankment with a maximum height of 26.1 feet. The top is the same type of concrete parapet wall as at the other embankments. The top of the parapet is at El 84.2. The top of the embankment is at El 81.2 and is covered with grass. The upstream face is a 2.5:1 slope covered with riprap, and the downstream slope is 2:1 covered with grass and weeds. Available drawings show the same type of zoned earthfill embankment as at the other sites, consisting mostly of impervious fill with a cutoff trench of impervious fill extending 15 feet below the base. The drawings show that the west dike is founded on dense to very dense sand and silt. There is no spillway or outlet at the west dike.

The south dike is a 360-foot long 5-foot high earthfill embankment that was raised in 1977 instead of adding a concrete parapet. The top is 12 feet wide and varies from El. 83.8 to 84.0. The side slopes are 2.5:1 upstream and downstream. At the time of inspection, the reservoir level was near the base of the embankment. A visual inspection was made of the south dike, however, a detailed discussion is not included in this report, since the south dike does not impound a significant depth of water and the downstream hazard potential is low.

c. Size Classification. For a dam to be classified as intermediate, it must have a height between 40 feet and 100 feet and a maximum storage capacity between 1,000 acre-feet and 50,000 acre-feet. Putnamville Reservoir Dam has been classified as "intermediate" on the basis of its storage capacity of 8,300 acre-feet. The East Dike and the West Dike are also classified as "intermediate" based on their impoundments of 3,200 acre-feet and 3,400 acre-feet, respectively.

d. Hazard Classification.

Dam: There are four houses located along Locust Street and Valley Road about 500 to 1,000 feet downstream of the dam (see Map of Flood Impact Areas). The foundations of these structures are approximately 10 feet above the bottom of the valley below the dam. An assumed failure of the dam would result in a flood wave 14 feet high, 500 feet downstream of the dam. Prior to failure, the water would be 5 feet deep due to discharge from the spillway. More than a few lives could be lost and an excessive amount of property damage could occur. Accordingly, the dam has been placed in the "high" hazard category.

East Dike: There are five houses located 200 to 400 feet downstream of the east dike (see Map of Flood Impact Areas). The foundations of these structures are less than 10 feet above the bottom of the valley downstream. An assumed failure of the east dike would result in a flood wave 14 feet high in the area of the houses. No flood water would occur prior to failure. More than a few lives could be lost and an excessive amount of property damage could occur. Accordingly, the east dike has been placed in the "high" hazard category.

West Dike: There is a trailer park with over 40 units and a gas station located 1,500 to 2,000 feet downstream of the west dike (see Map of Flood Impact Areas.) The foundations of these structures are approximately at the same elevation as the bottom of the valley downstream.

An assumed failure of the west dike would result in a flood wave 5 feet high 1,500 feet downstream. There would be no flood level prior to failure. More than a few lives could be lost and an excessive amount of property damage could occur. Accordingly, the west dike has been placed in the "high" hazard category.

e. Ownership. The dam is owned by the Salem and Beverly Water Supply Board, Water Filtration Plant, Beverly, Massachusetts 01915. Mr. Thomas Knowlton, Superintendent (telephone 617-922-2521) granted permission to enter the property and inspect the dam.

f. Operator. The dam is operated by personnel from the Salem and Beverly Water Supply Board.

g. Purpose of the Dam. The water in Putnamville Reservoir is used for domestic water supply by the Towns of Salem and Beverly. The reservoir is also used for fishing by permit only.

h. Design and Construction. Original construction of Putnamville Reservoir Dam and Dikes was completed in 1954. Drawings and specifications dated 1953 and prepared by Metcalf & Eddy, Inc. are available. Modifications to raise the reservoir by 5 feet were constructed in 1978. The modifications included raising the spillway crest; adding the parapet wall to the dam, east dike, and west dike; raising the south dike; and adding an upper level intake in the gatehouse. Drawings and specifications dated 1977 and prepared by Camp, Dresser, & McKee, Inc. are available for construction of the modifications.

There are no records of previous technical inspections or other data on the condition of the dam and dikes in the past.

i. Normal Operating Procedures. Personnel from the Salem and Beverly Water Supply Board reportedly visit the gatehouse once a week. At that time, they change the chart on the water level recorder in the gatehouse. The lower and middle intakes are operated regularly to fill and drain the reservoir. The upper intake is reportedly checked once a year. The reservoir was last lowered in 1978 during construction of modifications at the site.

1.3 Pertinent Data

a. Drainage Area. The drainage area is approximately 550 acres (0.85 square mile) and consists of hilly land (see Location May). The surface of the reservoir occupies about one-half of the drainage area. There are no other ponds or swamps in the remaining land portion of the

watershed. In general, the undeveloped portions of the drainage area consist of one-half woodland, and one-half open fields. Moderate residential development occurs just south of the reservoir.

b. Discharge. Discharge from Putnamville Reservoir Dam flows over the ogee crest on the spillway and into a concrete discharge channel. Flow through the outlet discharges about 2 miles east of the dam into Wenham Lake.

(1) Outlet: Size - 3 feet Invert El - 45.4. Discharge Capacity - 40 cfs at El 79.8.

(2) Maximum known flood at damsite: unknown.

(3) Ungated spillway capacity at top of dam: 960 cfs at El 83.8.

(4) Ungated spillway capacity at test flood elevation: 462 cfs at El 82.3.

(5) Gated spillway capacity at normal pool elevation: N/A (Not Applicable)

(6) Gated spillway capacity at test flood elevation: N/A

(7) Total spillway capacity at test flood elevation: 462 cfs at El 82.3.

(8) Total project discharge at top of dam: 960 cfs at El 83.8.

(9) Total project discharge at test flood elevation: 462 cfs at El 82.3.

c. Elevation (feet above National Geodetic Vertical Datum of 1929 (NGVD)). A benchmark was established at El 79.8 on the crest of the spillway. This elevation was given on as-built drawings dated 1977 and revised in 1979.

	Dam	East Dike	West Dike
(1) Streambed at toe of dam:	46.4	60.3	58.1
(2) Bottom of cutoff:	21.4	35.5	36.3
(3) Maximum tailwater:	Unknown	N/A	N/A

		Dam	East Dike	West Dike
(4)	Normal pool:	79.8	79.8	79.8
(5)	Full flood control pool:	N/A	N/A	N/A
(6)	Spillway crest:	79.8	N/A	N/A
(7)	Design surcharge (1977 design):	80.6	N/A	N/A
(8)	Top of dam (parapet):	83.8	83.9	84.2
	Top of embankment:	80.2	80.2	81.2
(9)	Test flood surcharge:	82.3	82.3	82.3

d. Reservoir (Length in feet)

(1) Normal pool: 4,500 at El 79.8

(2) Flood control pool: N/A

(3) Spillway crest pool: 4,500 at El 79.8

(4) Top of dam: 4,500 at El 83.8

(5) Test flood pool: 4,500 at El 82.3

e. Storage (acre-feet)		Dam	East Dike	West Dike
(1)	Normal Pool:	7,100	2,000	2,200
(2)	Flood control pool:	N/A	N/A	N/A
(3)	Spillway crest pool:	7,100	2,000	2,200
*(4)	Top of dam:	8,300	3,200	3,400
*(5)	Test flood pool:	7,825	2,725	2,925

*Based on the assumption that the surface area will not significantly increase with changes in pool elevation from 79.8 to 83.8.

f. Reservoir surface (acres)

(1) Normal pool: 290

(2) Flood-control pool: N/A

(3) Spillway crest: 290

*(4) Test flood pool: 290

*(5) Top of dam: 290

g. Dam and Dikes

	Dam	East Dike	West Dike
(1) Type:	earthfill	earthfill	earthfill
(2) Length:	1,400 ft.	2,100 ft.	700 ft.
(3) Height:	37.4	23.6	26.1
(4) Top width:	1 foot - reinforced concrete parapet 12 feet - earth embankment		
(5) Side slopes:	2.5:1 upstream; 2:1 downstream		
(6) Zoning:	mostly impervious with pervious under downstream slope and downstream base; rockfill toe drain		
(7) Impervious core:	impervious earth in upstream half of embankment		
(8) Cutoff:	trench extending 15 feet below base		
(9) Grout curtain:	none	none	none

h. Diversion and Regulating Tunnel: N/A

i. Spillway (dam only)

(1) Type: modified ogee crest

(2) Length of weir: 30 feet

*Based on the assumption that the surface area will not significantly increase with changes in pool elevation from 79.8 to 83.8.

(3) Crest elevation: 79.8

(4) Gates: none

(5) Upstream channel: earth channel with concrete retaining walls

(6) Downstream channel: concrete discharge channel and stilling basin, rockfill auxiliary stilling basin

j. Regulating Outlet (dam only)

(1) Invert El: 45.4 (lower intake)

(2) Size: 3-foot diameter

(3) Description: prestressed concrete cylinder pipe that discharges into Wenham Lake

(4) Control mechanism: gate valve

(5) Other:
middle intake - 3-foot diameter at El 54.7
upper intake - 2.5-foot diameter at El 70.0

SECTION 2

ENGINEERING DATA

2.1 General. The engineering data available for this Phase I inspection includes as-built drawings, specifications, and computations dated 1953 and prepared by Metcalf & Eddy, Inc. (see selected drawings and excerpt from specification in Appendix B). This data is available on microfilm at Metcalf & Eddy, Inc. Additional as-built drawings, specifications, and computations for raising of the reservoir were prepared in 1977 by Camp, Dresser, & McKee and are available at their office (excerpts in Appendix B). The only data available at State agencies is the permit application and bi-monthly progress reports for construction of the modifications. There are no records of previous inspections by State or County agencies.

We acknowledge the assistance and cooperation of personnel from the Massachusetts Department of Environmental Quality Engineering, Division of waterways; the Massachusetts Department of Public Works; and Camp, Dresser, & McKee. In addition, we acknowledge the assistance of Mr. Thomas Knowlton, Superintendent of Salem and Beverly Water Supply Board, who provided information on the history and operation of the dam.

2.2 Construction Records. Weekly construction reports, including field compaction tests and permeability tests, are available for the construction of the embankments in 1954. Bi-monthly progress reports for construction of the modifications are also available.

2.3 Operating Records. Although a water level recorder is maintained at the dam, the data is not tabulated and the records are incomplete.

2.4 Evaluation

a. Availability. The design engineering data for the dam and dikes is available.

b. Adequacy. The evaluation of the adequacy of the dam and dikes is based on a review of the design computations, record drawings, the visual inspection, past performance history, and engineering judgment.

c. Validity. Comparison of the available drawings with the field survey conducted during the Phase I inspection indicates that the available information is valid. However, elevations on the 1953 drawings are based on the

local Salem and Beverly datum. To convert to NGVD, add 4.7 feet to elevations shown on the 1953 drawings.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. The Phase I Inspection of Putnamville Reservoir Dam and Dikes was performed on June 16-17, 1981. A copy of the inspection checklist is given in Appendix A. There are no records of previous inspections by State or County agencies. Selected photographs taken during the Phase I inspection are given in Appendix C.

b. Dam and Dike Embankments. The dam, east, dike and west dike, are all zoned earthfill embankments with a concrete parapet at the top of the upstream slope. There are no vertical or horizontal displacements of the parapet wall which would indicate movement or settlement of the embankments. The concrete is in excellent condition. In places, a corner has been broken off near a joint, but the breaks are located on the top of the wall and are not due to erosion.

A dense growth of weeds, brush, and trees of various sizes occurs in many places at the downstream toe of the embankments. This growth prevents a thorough inspection of the toe drains and downstream areas for seepage, boils, and any unusual conditions.

Dam. North of the spillway, standing water was observed along most of the downstream toe. This is apparently seepage being collected by the filter and toe drain system. The water was not flowing and was clear. No boils were observed in the vicinity of the seepage.

Dumped riprap is located on the upstream face of the dam (see Photo No. 2). However, there is a section immediately south of the spillway where riprap is missing along the base of the concrete parapet for a distance of 23 feet.

The top of the embankment is covered with grass and some weeds except where tire tracks have worn through to the earthfill (see Photo No. 3). Trespassing is indicated by the remains of a campfire near the gatehouse.

The downstream slope is covered with grass and weeds (see Photos No. 4 and 5). Three casings containing tubes for

piezometers are located at the top, middle and bottom of the downstream slope. They have not been read recently and may not be usable. There is a footpath along the south side of the spillway channel, but no significant erosion has occurred there. Five animal burrows about 6-inches in diameter were observed on the downstream slope.

East Dike. There is a section of the upstream face where riprap is missing from the base of the concrete parapet (see Photo No. 14). This occurs near the bend in the embankment and exists for a distance of about 300 feet.

The top of the embankment is covered with grass and weeds (see Photo No. 13). Tire tracks have also been worn in the top.

The downstream slope is covered with grass and weeds, with brush along the toe (see Photos No. 15 and 16). Eight animal burrows from 1 to 6 inches in diameter were observed in several areas on the downstream slope. Several footpaths are located on the downstream slope near the abutments.

Seepage was observed at three locations along the downstream toe: 1) about 600 feet south of the north abutment, 2) downstream of the bend in the embankment (see Photo No. 17), and 3) near the south abutment. The seepage consists of wet ground with some pools of standing water. These areas are marked by the growth of cattails. The seepage was not flowing, and no boils were observed.

There are also two areas where pools of water have formed farther downstream next to Locust Street. One is near the north abutment (see Photo No. 18) and there is a slight flow toward the south where the land is lower. The other area is downstream of the bend in the embankment. The water is stagnant and orange-brown in color. It is not clear whether the water along Locust Street is due to poor surface drainage or due to seepage under the dike. Culverts under Locust Street shown on the drawings could not be located in the field.

West Dike. The riprap on the upstream face is generally adequate (see Photo No. 24), but there are a few areas where riprap is thin or missing. A tree is growing on the upstream slope near the right abutment. The top of the dike is covered with grass and weeds. It also contains tire tracks similar to the other embankments (see Photo No. 23).

Seepage was observed along the downstream toe in the central portion of the embankment (see Photo No. 26). This occurs as local pools of standing water surrounded by wet ground and overgrown with cattails. No flow or boils are associated with the seepage. The downstream slope is covered with grass and weeds, and brush is growing along the toe (see Photo No. 25). Three animal burrows about 6 inches in diameter are located at the downstream toe near the middle of the embankment.

South Dike. This structure differs from the other embankments by not having a concrete parapet. There was no seepage observed at the downstream toe. The downstream slope and toe are covered with grass and clear of other vegetation (see Photos No. 21 and 22). A footpath is located on the downstream slope near the center of the embankment. The top of the embankment shows no signs of settlement or movement. Tire tracks are present on the top (see Photo No. 19).

The upstream slope is protected with dumped riprap. Near the east abutment, however, this riprap is small in size and thinly placed (see Photo No. 20).

c. Appurtenant Structures. The only appurtenant structures are the spillway and the gatehouse at the main dam. The spillway is a concrete ogee weir without flashboards or stoplogs (see Photo No. 7). At the time of the inspection, no water was discharging over the spillway. The concrete on the crest of the spillway was in good condition with only slight efflorescence coming from two tie rod holes. A horizontal joint in the concrete is visible where the crest was raised in 1977. There was no debris on the crest of the spillway. The concrete of the discharge channel is in good condition (see Photo No. 8). There is an accumulation of rocks and other debris in the floor immediately downstream of the weir and in the stilling basin (see Photo No. 9). Below the discharge channel is an auxiliary stilling basin filled with dumped rock (see Photo No. 10). There is a minor growth of weeds and some wood debris in the rock fill. Water flowing at about 5 gpm was observed in the floor on both sides of the auxiliary stilling basin. Based on available drawings, this flow is probably discharge from drains under the sides of the spillway channel, although the outlets themselves were not visible under the rockfill. The flow was clear at the time of inspection.

The gatehouse is a brick superstructure with a concrete foundation (see Photo No. 11). The exterior is in good condition. Inside, there are three floor stands for operating the valves on the intake pipes (see Photo No. 12). All of the gate valves are reported to be operable. An access well to the pipes is located in the southeast corner of the gatehouse. However, the pipes could not be inspected because they were submerged by water in the lower level of the gatehouse. No portion of the piping at the dam was visible for inspection.

d. Reservoir Area. The reservoir area is sparsely developed, except along the south shore where moderate residential development begins about 300 feet from the reservoir. This development is located in Putnamville, a village of the Town of Danvers. The land around the reservoir is about half wooded and half cleared with low slopes.

e. Downstream Channel.

Dam: Discharge from the spillway and drainage below the dam flow into a natural stream channel. The stream could not be thoroughly inspected due to the dense growth of trees and brush that cover the entire downstream area. About 250 feet below dam, a box culvert 5-feet wide and 2-feet high conveys the stream flow under Locust Street. The water then flows under Valley Road and into Wenham Swamp about 1,000 feet downstream of the dam.

East Dike: The only flow from the east dike is seepage collected by the toe drains. The drawings show that this flow is carried by a series of concrete pipes that discharge into Wenham Swamp about 1,600 feet east of Locust Street. The pipes and culverts under Locust Street could not be located during the inspection.

West Dike: There are no outlet facilities at the West Dike. The area downstream is a broad, swampy valley that is densely wooded. There was no stream visible until west of the interchange of Route 95 and Route 1, about 2,000 feet downstream of the dike.

South Dike: A rockfill drain has been constructed to direct surface drainage away from the downstream toe of the embankment. There was no flow at the time of the inspection. There is no distinct stream bed farther downstream, but the topography indicates that water would flow southward across Locust Street and eventually into Frost Brook.

3.2 Evaluation. The visual inspection indicates that the dam and dikes at Putnamville Reservoir are in fair condition. The stated deficiencies and the measures to improve these conditions are outlined in Section 7.

The following conditions could affect the long-term performance of the dam and east dike:

a. Seepage in areas along the downstream toe. Uncontrolled seepage could lead to internal erosion of the embankment.

b. Dense growth of trees and brush in toe drains and downstream areas. The root systems could clog the toe drains and could provide pathways for seepage and internal erosion.

c. Obstructed culverts that carry flow downstream under Locust Street. Poor drainage at the downstream toe obscures seepage and causes unnecessary saturation.

d. Inadequate riprap at the top of the upstream slope. Wave action in unprotected zones could cause erosion of the earthfill and undermining of the parapet wall.

e. Rocks in the floor of the spillway discharge channel and the stilling basin. This could cause significant damage to the concrete during periods of high flows.

f. Animal burrows on the downstream slope. These can provide pathways for seepage through the embankment.

The following conditions could affect the long-term performance of the west dike:

a. Seepage in areas along the downstream toe. Uncontrolled seepage could lead to internal erosion of the embankment.

b. Dense growth of trees and brush in the toe drain and downstream area. The root systems could clog the toe drain and could provide pathways for seepage and internal erosion.

c. Inadequate riprap along the top of the upstream slope. Wave action in unprotected zones could cause erosion of the earthfill and undermining of the parapet wall.

d. Animal burrows on the downstream slope. These can provide pathways for seepage through the embankment.

The following condition could affect the long-term performance of the south dike:

a. Inadequate riprap on the upstream slope. This could lead to erosion of the upstream slope of the dam.

SECTION 4

OPERATING PROCEDURES

4.1 Operating Procedures

a. General. Putnamville Reservoir is operated as a pumped storage reservoir to replenish the main water supply at Wenham Lake. During the winter and spring when there is excess flow in the Ipswich River, water is pumped from the river into Putnamville Reservoir. In the summer and fall when the level in Wenham Lake is low, water is released from Putnamville Reservoir and flows by gravity through a pipeline into the lake. Water in Wenham Lake is then treated and released into the distribution system.

Flow into Putnamville Reservoir is controlled by the rate of pumping which is a maximum of 25 mgd (38.7 cfs). Water is carried to and from the reservoir by a 36-inch diameter pipeline. The lowest intake is used to fill the reservoir. The middle intake is used to release the water. The intakes are controlled by manually operated valves.

Personnel from the Salem and Beverly Water Supply Board reportedly visit the site at least once a week. At that time, they change the chart on a water level recorder located in the gatehouse. Samples of water in the reservoir are collected once a month for analysis. The Superintendant also reportedly inspects the site about every two months.

b. Warning System. There is no warning system in effect at the dam or dikes.

4.2 Maintenance Procedures

a. General. The embankments are reportedly mowed twice a year. At the time of inspection, grass and weeds several feet high were growing on the slopes. In addition, the toe drains and downstream areas were overgrown with brush and small trees.

Some debris, particularly large rocks, have accumulated in the concrete channel below the spillway.

b. Operating Facilities. The valves on the middle and lower intakes in the gatehouse are reportedly used regularly. The gate on the upper intake is reportedly checked once a year.

Minor repairs have reportedly been made to the gatehouse as a result of vandalism.

4.3 Evaluation. There is a program for regular operation and maintenance at the dam and dikes, however, additional maintenance is necessary. There is no program for technical inspections, a plan for surveillance during storms, or a warning system in effect at the dam or dikes. This is undesireable, considering that the dam and dikes are in the high hazard category. These programs should be implemented, as recommended in Section 7.3.

SECTION 5

EVALUATION OF HYDRAULIC/ HYDROLOGIC FEATURES

5.1 General. Putnamville Reservoir has a drainage area of 0.85 square miles of which 53 percent is the reservoir (see Drainage Area shown on Location Map). The land is gently rolling and sparsely developed.

Putnamville Reservoir has a surface area of approximately 290 acres. The maximum storage capacity impounded by the dam is 8,300 acre-feet at El 83.8.

The low level outlet at the dam can discharge a flow of 40 cfs when the reservoir is at El 79.8, which is the crest of the spillway. At this reservoir elevation and with no additional inflow, the outlet can lower the reservoir by 1 foot in about four days. This capacity is not adequate for readily lowering the reservoir in the event of an emergency at the dam or dikes. There is also no blow-off along the pipe, so that water from lowering the reservoir would be discharged into Wenham Lake, possibly causing flooding downstream.

5.2 Design Data. Hydraulic computations are available for the original spillway which was designed in 1953 and for raising the spillway in 1977. The computations are summarized below:

	1953	1977
Top of dam	78.8	83.8
El of spillway crest	74.7	79.8
El of reservoir before storm	74.7	79.8
Rainfall	16 in.	7 in.
Length of storm	72 hr.	24 hr.
Inflow from pumping	0	38.7 cfs
Peak outflow	202 cfs	80.6 cfs
Peak El of reservoir	76.2	80.6
Change in El of reservoir	1.5 ft.	0.8 ft.

5.3 Experience Data. There is no record of overtopping of the dam or dikes which were constructed in 1954. Pumping into the reservoir is stopped when the pool reaches 4 inches below the crest of the spillway. The superintendent stated that the highest reservoir level in the past was 1 inch above the crest of the spillway. This level would result in a discharge of 3 cfs.

5.4 Test Flood Analysis. Putnamville Reservoir Dam and Dikes have been classified in the "intermediate" size and "high" hazard categories. According to the Corps of Engineers guidelines, a test flood equal to the full PMF (Probable Maximum Flood) should be used to evaluate the capacity of the spillway.

The PMF rate for the 0.85 square mile watershed was calculated to be 2,850 cfs per square mile of drainage area. This calculation is based on the average slope of 4 percent in the drainage area, the pond-plus-swamp area to drainage area ratio of 0 percent, and the U.S. Army Corps of Engineers guide curves for Maximum Probable Flood Peak Flow Rates (dated December 1977).

Applying the full PMF rate to the 0.85 square mile drainage area results in a peak test flood inflow of 2,420 cfs. By adjusting the test flood inflow for surcharge storage, the peak test flood outflow was calculated to be 462 cfs (544 cfs per square mile). During the test flood, the reservoir level would rise to El 82.3.

Hydraulic analyses indicate that the spillway can discharge 960 cfs or 208 percent of the test flood outflow with the reservoir at El 83.8, which is the low point on the top of the dam and dikes.

5.5 Failure Analyses.

Dam: The peak discharge rate due to failure of the dam was calculated to be 94,000 cfs with the reservoir at El 82.3. This calculation is based on a maximum head of 35.9 feet and an assumed 260-foot wide breach occurring in the embankment section north of the spillway. Failure of the dam would produce a downstream flood wave 14 feet deep as compared to a channel flow 5 feet deep prior to failure.

There are four houses located in the valley 500 to 1,000 feet downstream of the dam. The foundations of these structures are approximately 10 feet above the bottom of the valley. Due to the configuration of the valley, little attenuation

of the flood flow is expected until it reaches Wenham Swamp, east of the houses. An assumed failure of the dam could result in a flood wave that would rise above the foundation of the houses downstream. This could result in the possible loss of more than a few lives and an excessive amount of property damage. Accordingly, the dam has been placed in the "high" hazard category.

East Dike: The peak discharge rate due to failure of the east dike was calculated to be 52,000 cfs with the reservoir at El 82.3. This calculation is based on a maximum head of 22 feet and an assumed 300-foot wide breach occurring in the highest section of the embankment. Failure of the east dike would produce a downstream flood wave 14 feet deep as compared to no downstream flow prior to failure.

There are five houses located along Locust Street 200 to 400 feet downstream of the east dike. The foundations of these structures are less than 10 feet above the bottom of the valley downstream of the east dike. Due to the configuration of the land downstream, little attenuation of the flood flow is expected. An assumed failure of the east dike could result in a flood wave that would rise above the foundation level of the houses downstream. This could result in the possible loss of more than a few lives and an excessive amount of property damage. Accordingly, the east dike has been placed in the 'high" hazard category.

West Dike: The peak discharge rate due to failure of the west dike was calculated to be 41,800 cfs with the reservoir at El 82.3. This calculation is based on a maximum head of 25.6 feet and an assumed 192-foot wide breach occurring in the highest section of the embankment. Failure of the west dike would produce a downstream flood wave 8 feet deep as compared to no downstream flow prior to failure.

There is a gas station and a trailer park located in the valley 1,500 to 2,000 feet downstream of the west dike. The foundations of these structures are approximately at the same elevation as the bottom of the valley downstream of the west dike. Due to the configuration of the valley, some attenuation of the flood flow is expected, however, the wave would still be about 5 feet deep across Route 1, 1,500 feet downstream. An assumed failure of the west dike could result in a flood wave that would rise above the foundation level of the trailer houses and gas station. This could result in the possible loss of more than a few lives and an excessive amount of property damage. Accordingly, the dam has been placed in the "high" hazard category.

SECTION 6

STRUCTURAL STABILITY

6.1 Visual Observations. The evaluation of the structural stability of Putnamville Reservoir Dam and Dikes is based on a review of available engineering data, and the visual inspection conducted on June 16-17, 1980.

As discussed in Section 3, Visual Inspection, the dam and dikes are in good condition. Seepage was observed along the downstream toe of the dam, east dike, and west dike. No settlement of the embankments was visible. The grass cover has been worn off in places by vehicular traffic and trespassing. However, no significant erosion has taken place in these areas. A thick growth of brush and trees exists along the downstream toe of the main dam, east dike, and west dike.

6.2 Design and Construction Data. Construction of Putnamville Reservoir Dam and Dike was completed in 1954. Drawings dated 1953 prepared by Metcalf & Eddy, Inc. show the as- built construction of the dam and dikes (see Figures B-1 through B-9).

The drawings show that the dam and dikes are zoned earthfill embankments founded on bedrock or glacial till. The embankments are constructed mostly of impervious material, with "most impervious" fill in the upstream half of the embankments and in the cutoff trench. The trench extends 15 feet below the base of the embankments or to the top of bedrock if bedrock is less than 15 feet deep. Underlying the downstream slopes, there is a filter blanket of pervious material. A pervious layer of sand and gravel is also located at the base of the embankments on the downstream side. This layer and the filter blanket are connected to a rockfill drain along the downstream toe. The side slopes of the embankments are 2.5:1 upstream and 2:1 downstream.

Specifications for construction of the dam and dike embankments are available. They include details on the types of earth materials, riprap, and concrete used in construction. Selected portions of the specifications are given in Appendix B.

Weekly construction reports are available that give the results of field compaction and permeability tests on the fill materials. The embankments were compacted with a rubber tired roller, a sheepsfoot roller, and a Barco tamper. A review of construction reports show that the impervious

fill was compacted to 12 to 100+ percent (122 to 151 lb/cu ft) of laboratory optimum and had a permeability of 2x10-5 to 9.5x10-6 cm/sec. The pervious fill was compacted to 90 to 100 percent (133 to 141 lb/cu ft) of laboratory optimum and had a permeability of 9.2x10-4 to 1.9x10-5 cm/sec. There is no information on the shear strength of materials in the embankments.

6.3 Post-Construction Changes. Since the original construction of the dam and dikes, modifications were made in 1978 to raise the reservoir 5 feet. These modifications included adding the concrete parapet to the dam, east dike, and west dike; raising the top of the south dike; raising the crest of the spillway; and adding the upper intake in the gatehouse. Selected as-built drawings of these modifications are included in Appendix B.

6.4 Seismic Stability. The dam and dikes are located in Seismic Zone No. 3. Phase I Guidelines recommend, as a minimum, that suitable analysis by conventional equivalent static load methods should be on record for dams in Zone No. 3. This type of stability analysis was done in 1953 for the original spillway structure. However, as far as can be determined, no such analyses have been made on the dam or dike embankments.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Assessment of Dam and Dikes

a. Condition. As a result of the visual inspection, the review of available data, and limited information on operation and maintenance, the dam and dikes are considered to be in fair condition. This is primarily due to the seepage observed at the downstream toe of the embankments. The following deficiencies must also be corrected to assure the continued performance of the dam, east dike, and west dike: a dense growth of brush and trees at the toe and in the downstream areas; inadequate riprap in places along the top of the upstream slopes; and animal burrows on the downstream slopes. At the dam, additional deficiencies are the accumulation of debris, particularly rocks, in the spillway channel and stilling basin; and the inadequate capacity of the low-level outlet. The only deficiency at the south dike is inadequate riprap on the upstream slope.

The peak test flood (full PMF) outflow is estimated to be 462 cfs with the reservoir at El 82.3. The test flood would not overtop the dam or the dikes. Hydraulic analyses indicate that the spillway can discharge 960 cfs or 208 percent of the test flood outflow before the low point on the top of the dam and dikes is overtopped.

b. Adequacy. The lack of detailed design and construction data did not allow for a definitive review. Therefore, the evaluation of the dam and dikes is based on a review of the available date, the visual inspection, past performance and engineering judgment.

c. Urgency. The recommendations and remedial measures outlined below should be implemented by the Owner within one year after receipt of this Phase I Inspection Report.

7.2 Recommendations. It is recommended that the Owner employ a qualified registered engineer to conduct the following studies:

a. Install and monitor piezometers to evaluate the seepage through the dam, east dike and west dike. The abandoned piezometers at the dam should be rehabilitated or replaced. The monitoring program should cover periods

when the reservoir is above the spillway crest. The readings should be plotted and evaluated on a regular basis.

b. Design a system to effectively drain standing water from the downstream toe of the dam, east dike, and west dike.

c. Develop procedures for clearing trees and brush from the toe drains and for a distance of 25 feet downstream of the dam, east dike, and west dike. Additional clearing is needed along the channel downstream of the dam, around culverts under Locust Street, and in areas of standing water. A tree on the upstream slope of the west dike should also be removed. All stumps and roots removed should be backfilled with select material.

d. Design adequate riprap for the upstream slope of the dam, east dike, west dike, and south dike.

e. Further investigate the extent of animal burrows on the downstream slope and determine a procedure for backfilling these areas.

f. Evaluate the seismic stability of the dam, east dike, and west dike.

g. Conduct further hydraulic studies and determine a means to increase the discharge capacity of the low-level outlet. The engineer should evaluate the possibility of discharging water through the pumping station and back into the Ipswich River.

The Owner should implement the recommendations of the Engineer.

7.3 Remedial Measures

a. Operating and Maintenance Procedures. It is recommended that the Owner accomplish the following:

(1) Remove rocks and debris from the spillway discharge channel and stilling basin.

(2) Institute a definite plan for surveillance of the dam, dikes, and spillway during and after periods of heavy rainfall and a plan to warn people in downstream areas in the event of an emergency at the dam or the dikes.

(3) Implement a systematic program of maintenance inspections. As a minimum, the inspection program should consist of a monthly inspection of the dam, dikes, and appurtenances and be supplemented by additional inspections during and after severe storms. All repairs and maintenance should be undertaken in compliance with all applicable State regulations. The maintenance program should include removal of any debris caught on the spillway weir or accumulated in the discharge channel and stilling basin downstream.

(4) Institute a program of technical inspections of the dam and dikes on an annual basis.

7.4 Alternatives. There are no practical alternatives to the above recommendations.

APPENDIX A

PERIODIC INSPECTION CHECKLIST

PUTNAMVILLE RESERVOIR DAM AND DIKES

PERIODIC INSPECTION

PARTY ORGANIZATION

PROJECT Putnamville Reservoir

DATE June 16-17, 1981

TIME 8:30 - 4:30

WEATHER Sunny & hot

W.S. ELEV. 79.4 U.S.

Abbreviations:
U.S. - upstream
D.S. - downstream
N/A - not applicable

46 D.S. Dam
60 D.S. east dike
58 D.S. west dike

PARTY:

1. Carol Sweet - Metcalf & Eddy - Geotechnical
2. Mike Larson - Metcalf & Eddy - Geotechnical
3. Ed Greco - Metcalf & Eddy - Geotechnical
4. Bill Checchi - Metcalf & Eddy Geotechnical
5. Jim Peter - Metcalf & Eddy - Geotechnical
6. Lyle Branagan - Metcalf & Eddy - Hydraulic/Hydrologic
7. Reginald Barron - Consultant to Metcalf & Eddy
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Dam & dike embankments	Sweet/Greco/Barron	
2.	Spillway	Branagan/Sweet/Barron	
3.	Gatehouse	Branagan/Sweet/Barron	
4.			
5.			
6.			

PERIODIC INSPECTION CHECK LIST

PROJECT Putnamville Reservoir DATE June 16, 1981

PROJECT FEATURE Dam NAME Sweet/Greco

DISCIPLINE Geotechnical NAME Barron

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation (top of parapet)	varies from 83.8 to 83.9
Current Pool Elevation	79.4
Maximum Impoundment to Date	79.9
Surface Cracks	none visible - slopes & downstream toe covered with high weeds & brush
Pavement Condition	not applicable (N/A)
Movement or Settlement of Crest	None except slight depression around top piezometer
Lateral Movement	none-concrete parapet is straight
Vertical Alignment	flat
Horizontal Alignment	one bend at spillway
Condition at Abutment and at Concrete Structures	good-no visible erosion or settlement along concrete parapet or spillway-abutments tie into natural ground
Indications of Movement of Structural Items on Slopes	none
Trespassing on Slopes	footpath on downstream slope near south side of spillway - camp fire on top of dam-5 animal holes on downstream slope
Sloughing or Erosion of Slopes or Abutments	sparse topsoil and vegetation at several locations
Rock Slope Protection - Riprap Failures	riprap missing for a distance of 23 feet from south side of spillway
Unusual Movement or Cracking at or near Toes	none visible, but growth of weeds & brush obscures inspection
Unusual Embankment or Downstream Seepage	standing water along downstream toe - no visible flow - water is clear
Piping or Boils	none visible
Foundation Drainage Features	pervious filter under downstream slope
Toe Drains	rockfill toe drain connected to filter
Instrumentation System	abandoned piezometers at top, middle, and bottom of upper downstream slope

PERIODIC INSPECTION CHECK LIST

PROJECT Putnamville Reservoir DATE June 16, 1981

PROJECT FEATURE Spillway NAME Sweet/Barron

DISCIPLINE Geotechnical/Hydraulic NAME Branagan

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	Fine sand with little gravel in floor, concrete retaining walls on sides
General Condition	fair
Loose Rock Overhanging Channel	none
Trees Overhanging Channel	none
Floor of Approach Channel	clear of debris
b. Weir and Training Walls	concrete - ogee type
General Condition of Concrete	good - vertical hairline crack, horizontal joint where raised in 1978
Rust or Staining	none
Spalling	none
Any Visible Reinforcing	none
Any Seepage or Efflorescence	slight efflorescence from two tie rod holes
Drain Holes	none
c. Discharge Channel	
General Condition	good
Loose Rock Overhanging Channel	none
Trees Overhanging Channel	none next to channel
Floor of Channel	rocks & other debris have accumulated below weir & in stilling basin
Other Obstructions	none

d. Auxiliary Stilling Basin

Condition of concrete - excellent

Obstructions - none, no overhanging trees

Floor of channel - rockfill with slight growth of brush

Underdrains from sides of spillway channel each discharging ± 5 gpm into Auxiliary basin

PERIODIC INSPECTION CHECK LIST

PROJECT Putnamville Reservoir **DATE** June 16, 1981

PROJECT FEATURE Gatehouse **NAME** Sweet/Barron

DISCIPLINE Geotechnical/Hydraulic **NAME** Branagan

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	brick superstructure concrete foundation
General Condition	good
Condition of Joints	good
Spalling	none
Visible Reinforcing	none
Rusting or Staining	none
Any Seepage or Efflorescence	none
Joint Alignment	good
Unusual Seepage or Leaks in Gate	submerged
Cracks	none
Rusting or Corrosion of Steel	none
b. Mechanical and Electrical	
Air Vents	openings in roof
Float Wells	Bisson's water level recorder
Crane Hoist	none
Elevator	none
Hydraulic System	none
Service Gates	three 30 in. gates for lower, middle, and upper intakes
Emergency Gates	none
Lightning Protection System	unknown
Emergency Power System	none
Wiring and Lighting System in Gate Chamber	wiring to run 10 compressors to aerate reservoir - no interior lighting

PERIODIC INSPECTION CHECK LIST

PROJECT Putnamville Reservoir DATE June 16, 1981

PROJECT FEATURE East Dike NAME Sweet/Greco

DISCIPLINE Geotechnical NAME Barron

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation (top of parapet)	varies from 83.9 to 84.1
Current Pool Elevation	79.4
Maximum Impoundment to Date	79.9
Surface Cracks	none- slopes & downstream toe overgrown with brush & weeds
Pavement Condition	not applicable (N/A)
Movement or Settlement of Crest	none visible
Lateral Movement	none visible
Vertical Alignment	flat
Horizontal Alignment	one slight bend
Condition at Abutment and at Concrete Structures	good-no erosion or settlement abutments tie into natural ground
Indications of Movement of Structural Items on Slopes	none - no displacements in parapet
Trespassing on Slopes	8 animal holes on downstream slope, footpaths at abutments
Sloughing or Erosion of Slopes or Abutments	none
Rock Slope Protection - Riprap Failures	riprap missing from upstream base of parapet near bend in dike - 300 ft. lon
Unusual Movement or Cracking at or near Toes	none visible - inspection obscured by growth of vegetation
Unusual Embankment or Downstream Seepage	two areas of standing water with growth of cattails - several pools of water along Locust Street
Piping or Boils	no boils visible near seep areas
Foundation Drainage Features	pervious filter under downstream slope
Toe Drains	rockfill toe drain connected to filter
Instrumentation System	none visible

PERIODIC INSPECTION CHECK LIST

PROJECT Putnamville Reservoir DATE June 17, 1981

PROJECT FEATURE South Dike NAME Sweet/Greco

DISCIPLINE Geotechnical NAME Barron

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation	varies from 83.7 to 84.0
Current Pool Elevation	79.4
Maximum Impoundment to Date	79.9
Surface Cracks	none visible
Pavement Condition	not applicable (N/A)
Movement or Settlement of Crest	none visible
Lateral Movement	none visible
Vertical Alignment	flat
Horizontal Alignment	straight
Condition at Abutment and at Concrete Structures	good-no erosion or settlement abutments tie into natural ground
Indications of Movement of Structural Items on Slopes	N/A no structural items
Trespassing on Slopes	footpath on downstream slope near center of dam
Sloughing or Erosion of Slopes or Abutments	none
Rock Slope Protection - Riprap Failures	riprap is thin near east abutment
Unusual Movement or Cracking at or near Toes	none visible
Unusual Embankment or Downstream Seepage	none - reservoir level near toe of embankment
Piping or Boils	none visible
Foundation Drainage Features	pervious filter at base of embankment on downstream side
Toe Drains	none
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT Putnamville Reservoir DATE June 17, 1981

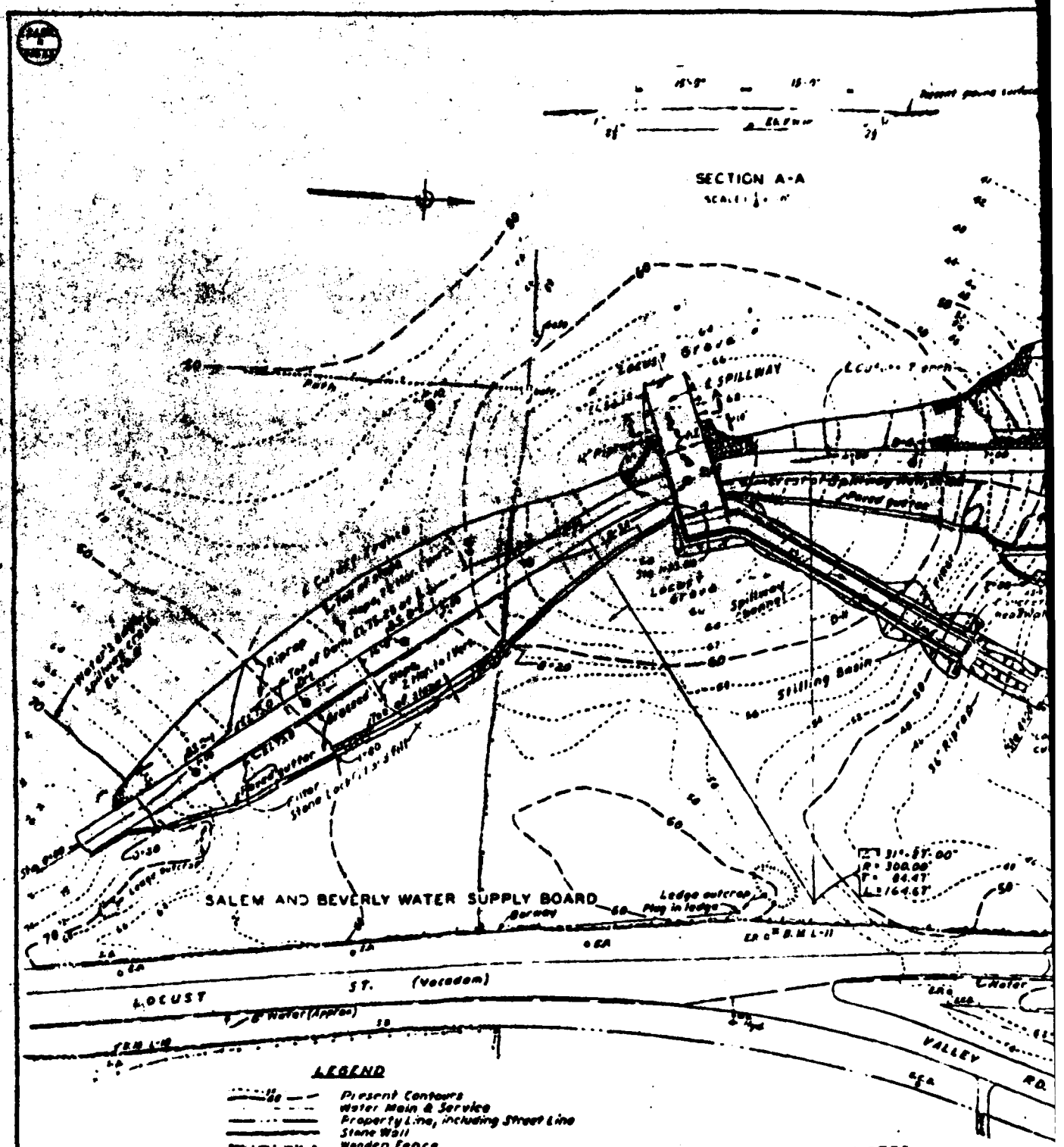
PROJECT FEATURE West Dike NAME Sweet/Greco

DISCIPLINE Geotechnical NAME Barron

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation (top of parapet)	84.2
Current Pool Elevation	79.4
Maximum Impoundment to Date	79.9
Surface Cracks	none visible
Pavement Condition	not applicable (N/A)
Movement or Settlement of Crest	none visible
Lateral Movement	none visible
Vertical Alignment	flat
Horizontal Alignment	straight
Condition at Abutment and at Concrete Structures	good-no erosion or settlement abutments tie into natural ground
Indications of Movement of Structural Items on Slopes	none no displacements in parapet
Trespassing on Slopes	3 animal holes on downstream slope, no footpaths
Sloughing or Erosion of Slopes or Abutments	none visible
Rock Slope Protection - Riprap Failures	riprap is thin in sections along upstream base of concrete parapet, small tree growing in riprap
Unusual Movement or Cracking at or near Toes	none visible, but heavily overgrown
Unusual Embankment or Downstream Seepage	several small pools of standing water & cattails near center of dike
Piping or Boils	none visible
Foundation Drainage Features	pervious filter under downstream slope
Toe Drains	rockfill toe drain connected to filter
Instrumentation System	none

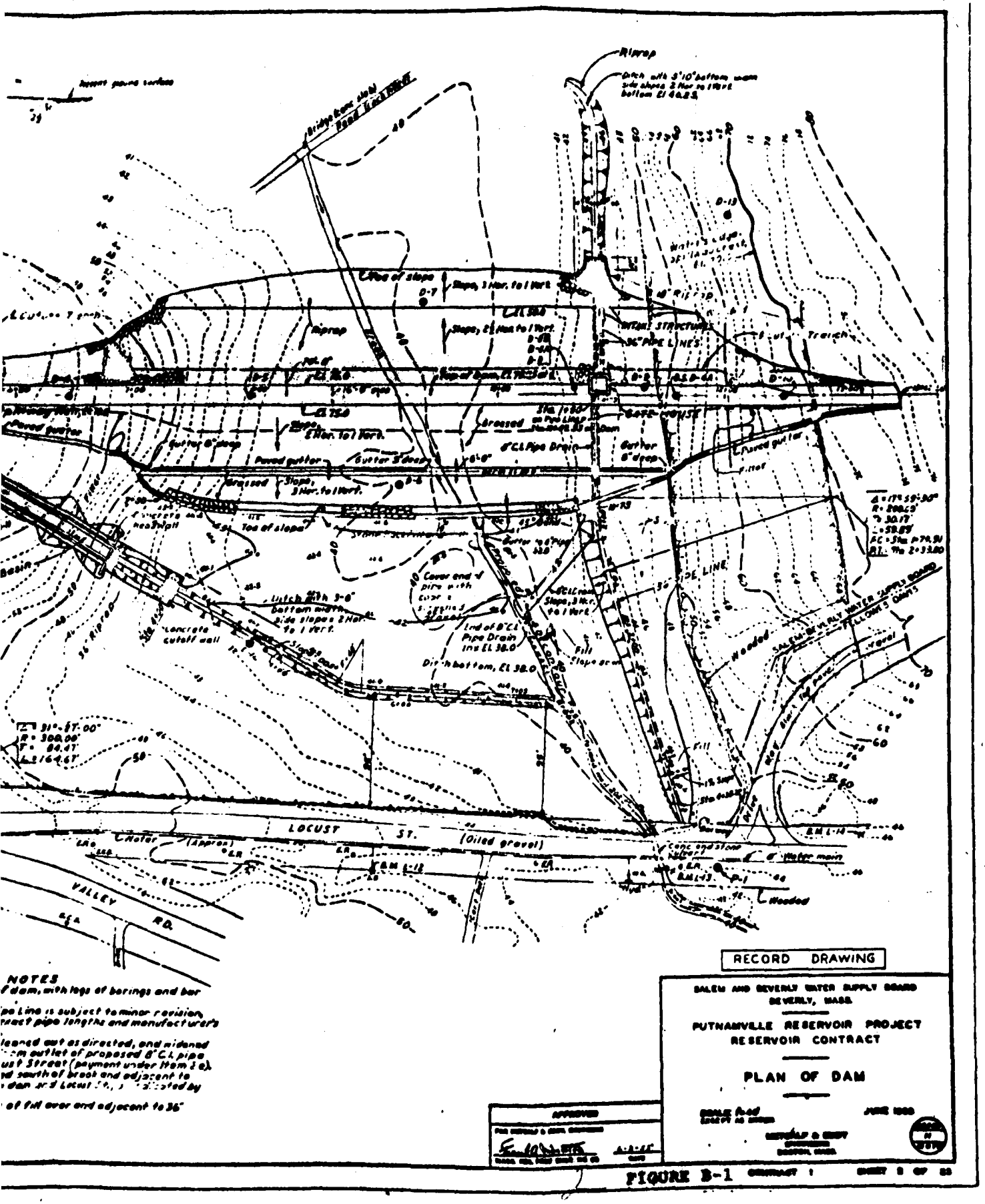
APPENDIX B

PLANS OF DAM AND DIKES



NOTES

1. See Sheet 3 for profile of dam, with logs of borings and soundings for dam.
2. Radius for curve in 36" Pipe Line is subject to minor revi... as approved, to conform to exact pipe lengths and manufac... standard for beveled pipes.
3. Existing brook shall be cleaned out as directed, and wi... and deepened if directed, from outlet of proposed 8" C.L. ... drain to the culvert of Locust Street (payment under Ite...
4. Random fill shall be placed south of brook and adjacent ... north bank of brook, between dam and Locust St., ... proposed contours and slope.
5. See Sheet 15 for details of fill over and adjacent to 36... pipeline.



NOTES

f dam, with logs of borings and bor

pe Line is subject to minor revision, ract pipe lengths and manufacturer's

leaned out as directed, and widened m outlet of proposed 8" C.I. pipe ust Street (payment under Item 2 e). d south of brook and adjacent to dam and Locust St., as directed by

of fill over and adjacent to 36"

RECORD DRAWING

SALEM AND BEVERLY WATER SUPPLY BOARD
BEVERLY, MASS.

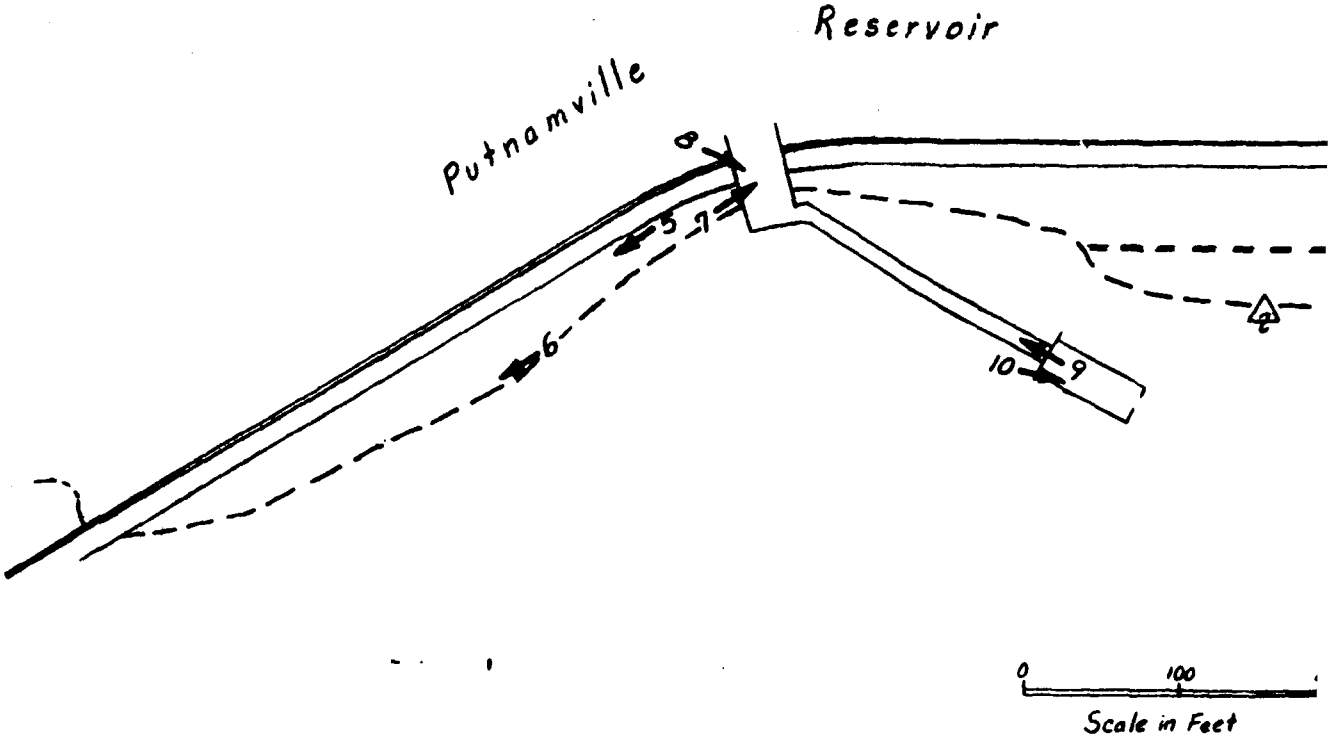
PUTNAMVILLE RESERVOIR PROJECT
RESERVOIR CONTRACT

PLAN OF DAM

SCALE As noted
DATE JUNE 1950

APPROVED

FIGURE B-1 CONTRACT 1 SHEET 8 OF 22

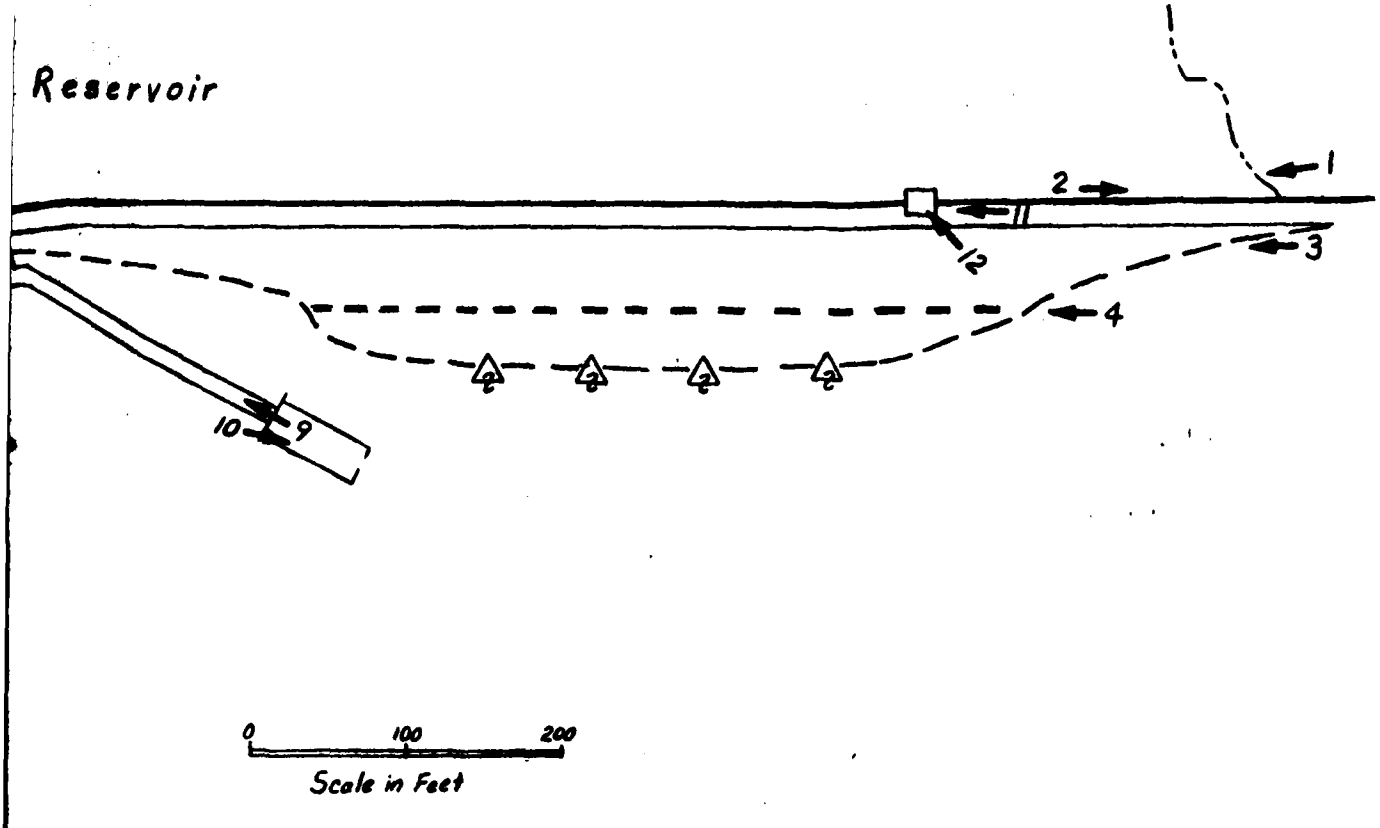


LEGEND

3 → location and number of photograph

4 △ location of seepage area

1



LEGEND

tion and number
photograph

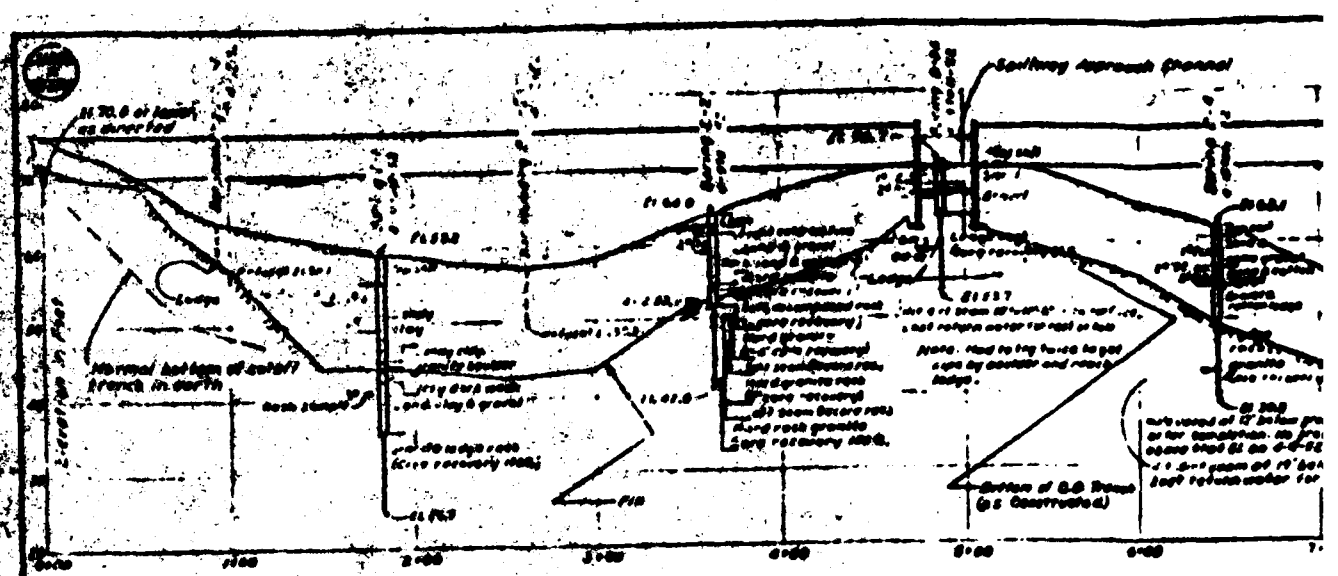
tion of seepage area

FIGURE B-1A

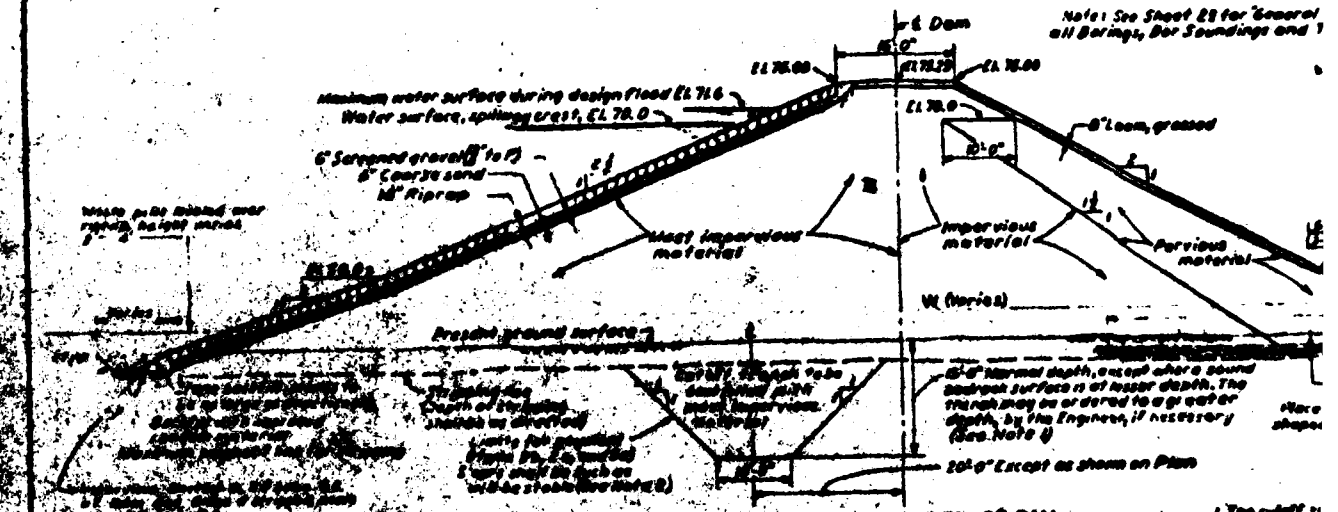
LOCATIONS OF PHOTOGRAPHS
AND SEEPAGE AREAS

Putnamville Reservoir Dam

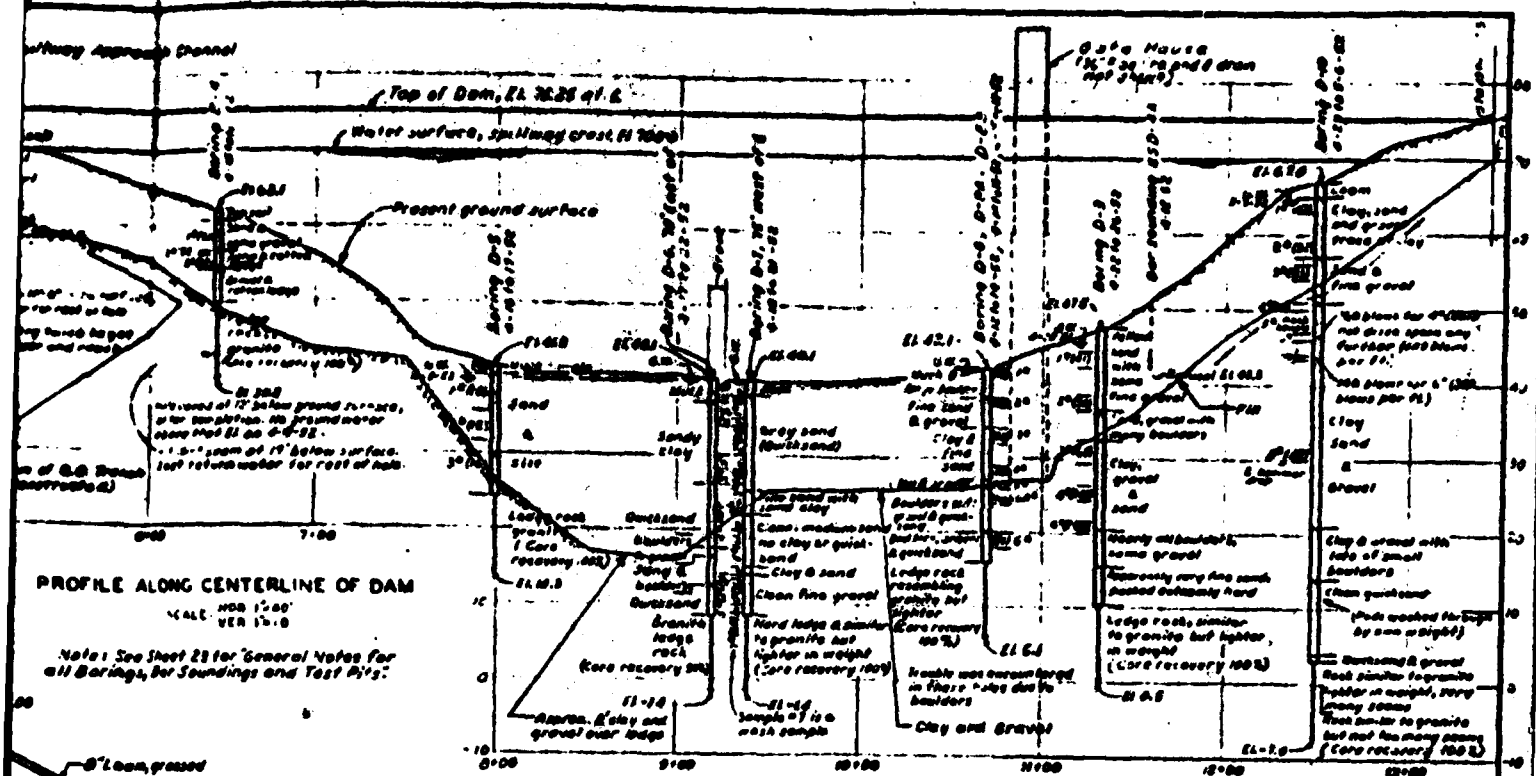
J



PROFILE ALONG CENTERLIN



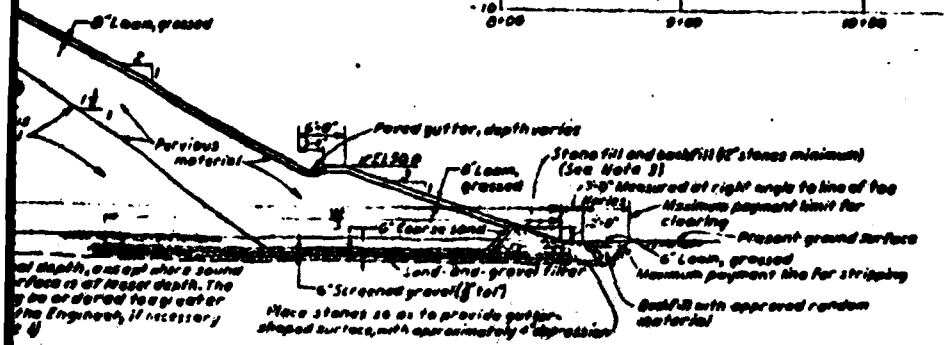
TYPICAL SECTION OF DAM
WHERE PRESENT GROUND SURFACE AT DOWNSTREAM TOE IS BELOW EL. 500

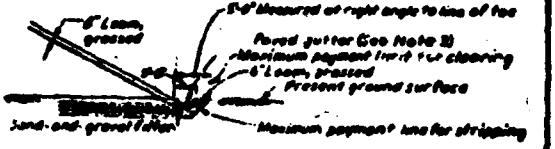


PROFILE ALONG CENTERLINE OF DAM

SCALE: HOR 1"=100'
VER 1"=10'

Note: See Sheet 23 for "General Notes for all Borings, Bor Soundings and Test Pits".



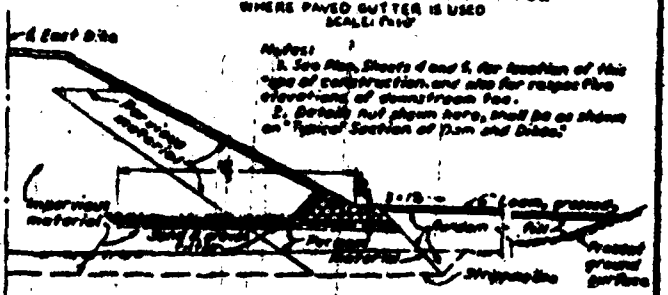


Note: See Plans for proposed locations of paved gutter at downstream toe. Details not shown here shall be as shown on "Typical Sections of Dam and Dikes".

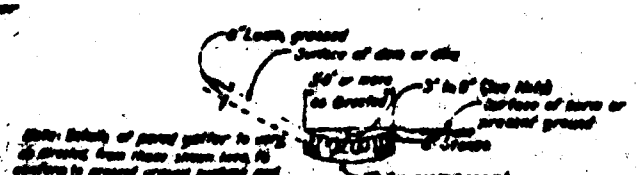
TYPICAL SECTION OF DOWNSTREAM TOE
WHERE PAVED GUTTER IS USED
SCALE: 1"=5'

NOTES

1. The cutoff trench shall extend to sound bedrock where such bedrock is not more than 15 ft. below present ground surface, and elsewhere if directed. The normal depth (8 ft.) of the cutoff trench shall be reduced, as directed, near the ends of the dam and dikes and also wherever the present ground surface at centerline of dam or dikes is above El. 68.0 approximately.
2. The inner side slopes shown for cutoff trench are for payment for earth excavation and backfill. The actual slopes may be different.
3. The exposed surface of all stone fill and backfill shall be smoothed up by use of crushed rock, as directed. The stone fill and backfill shown at the downstream toe shall be constructed where indicated on the Plans or where directed. All other locations, a paved gutter shall be constructed at the downstream toe, in accordance with "Typical Section of Downstream Toe Where Paved Gutter is Used".
4. The sand-and-gravel filter on downstream side of dam and dikes shall be omitted where the present ground surface at the downstream toe is at or above El. 78.0.



TYPICAL SECTION SHOWING DOWNSTREAM TOE OF EAST DIKE
WHERE FILL IS REQUIRED
SCALE: 1"=5'



TYPICAL PAVED GUTTER
SCALE: ½"=1'

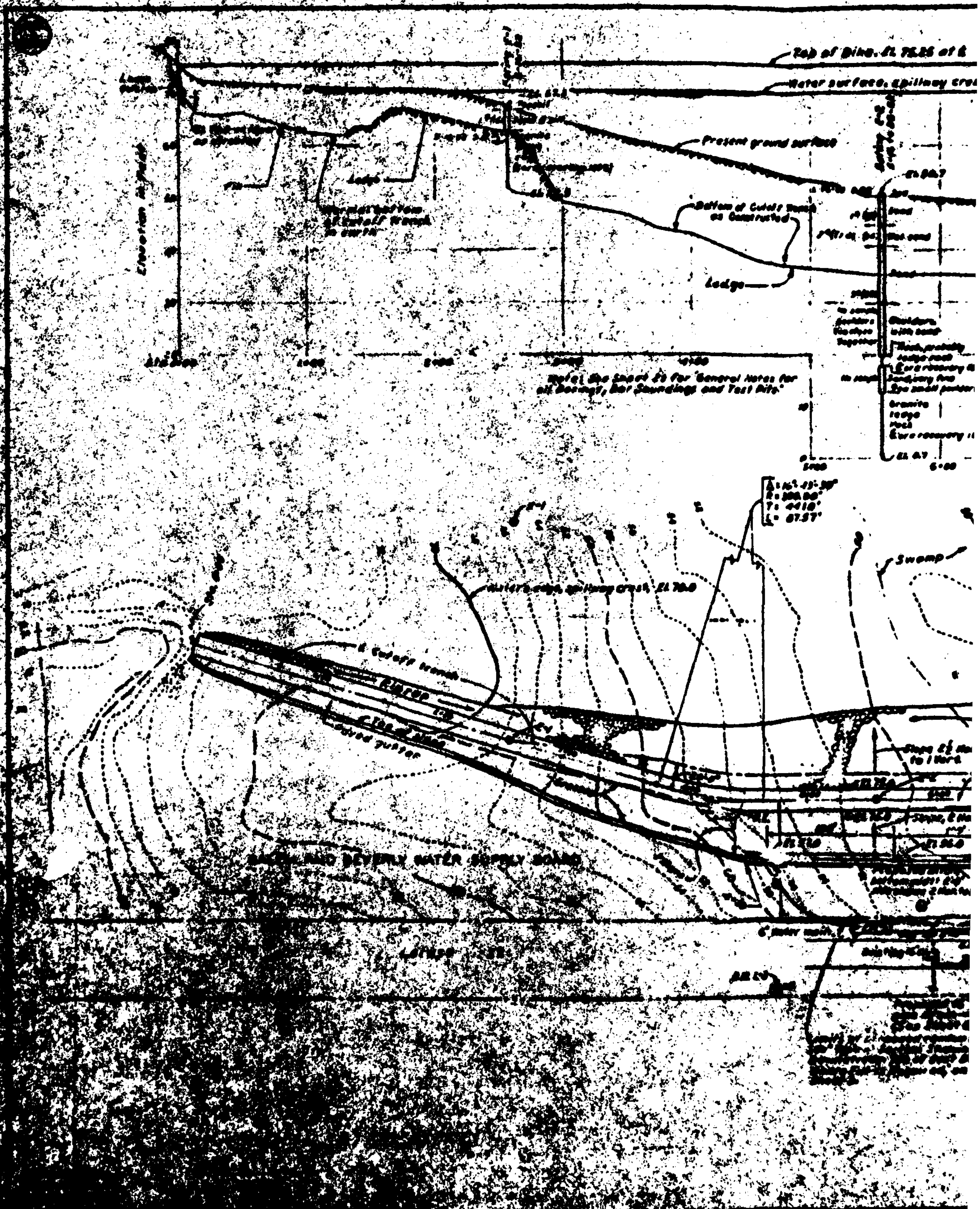
RECORD DRAWING

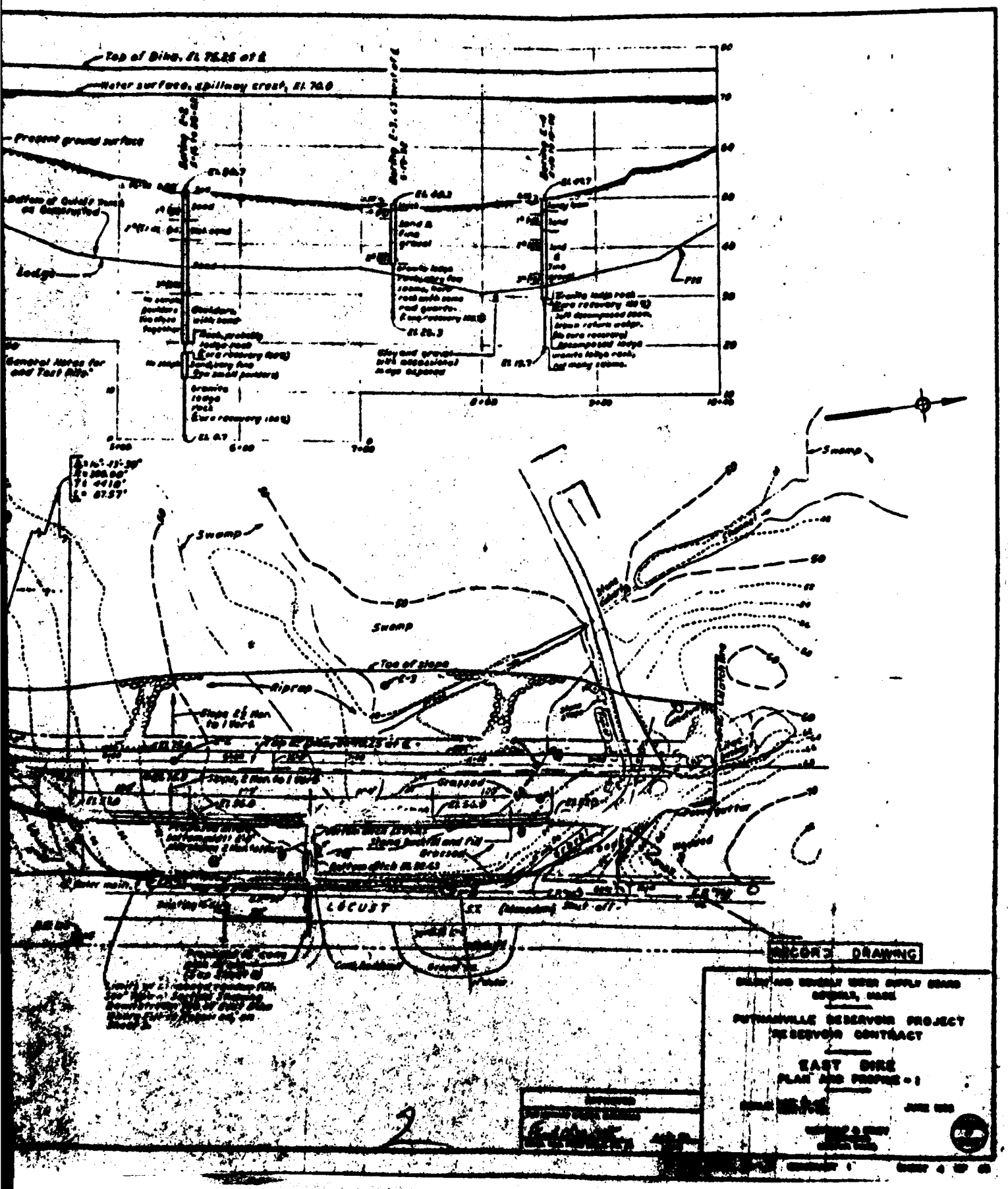
SALEM AND BEVERLY WATER SUPPLY BOARD
BEVERLY, MASS.

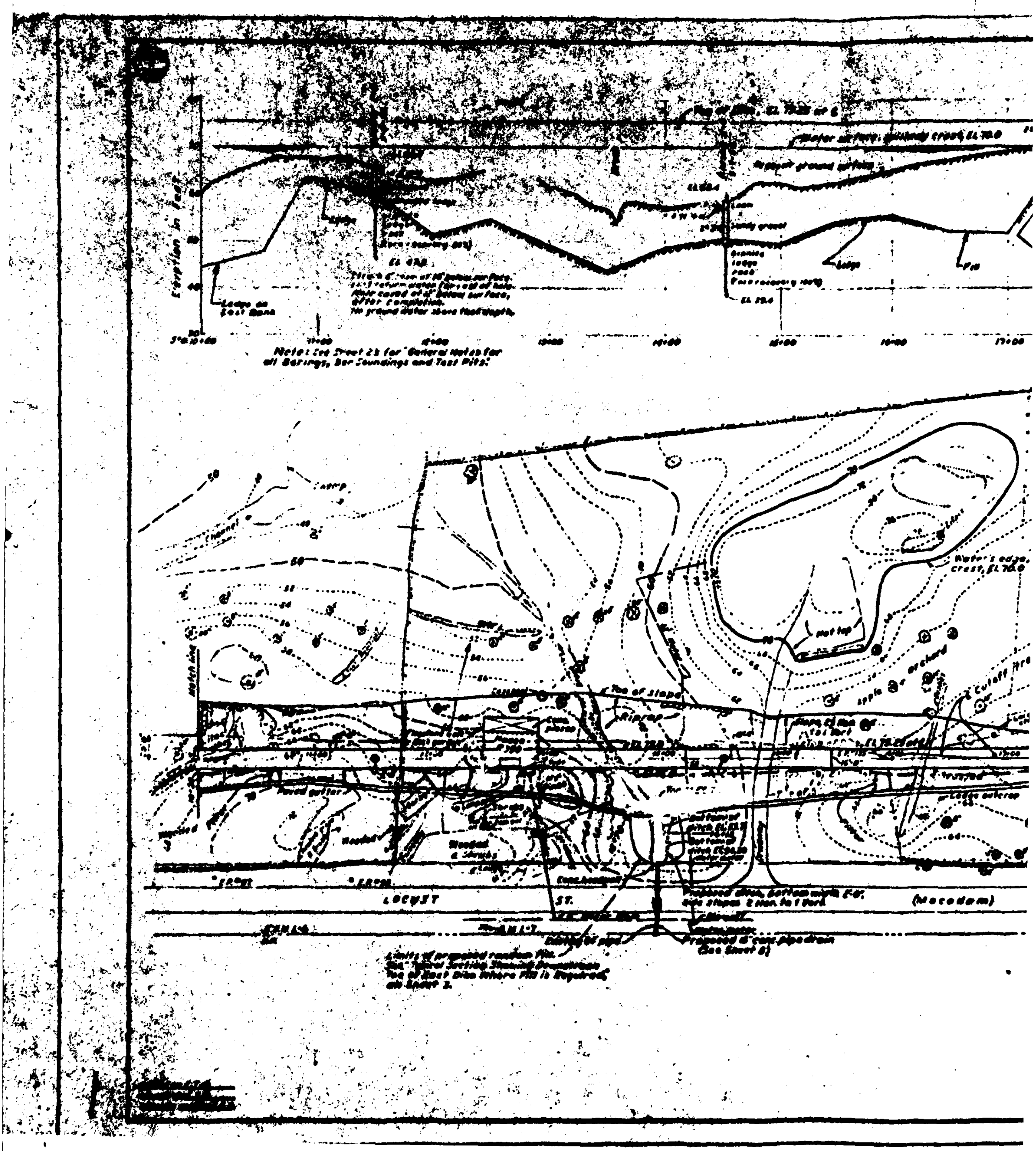
PUTNAMVILLE RESERVOIR PROJECT
RESERVOIR CONTRACT

PROFILE OF DAM
TYPICAL SECTIONS OF DAM AND DIKES

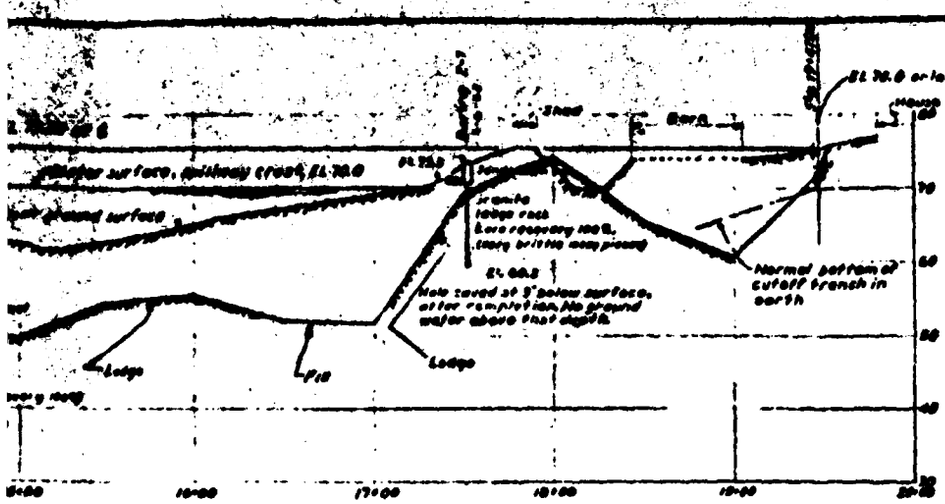
SCALE AS SHOWN — JUNE 1950

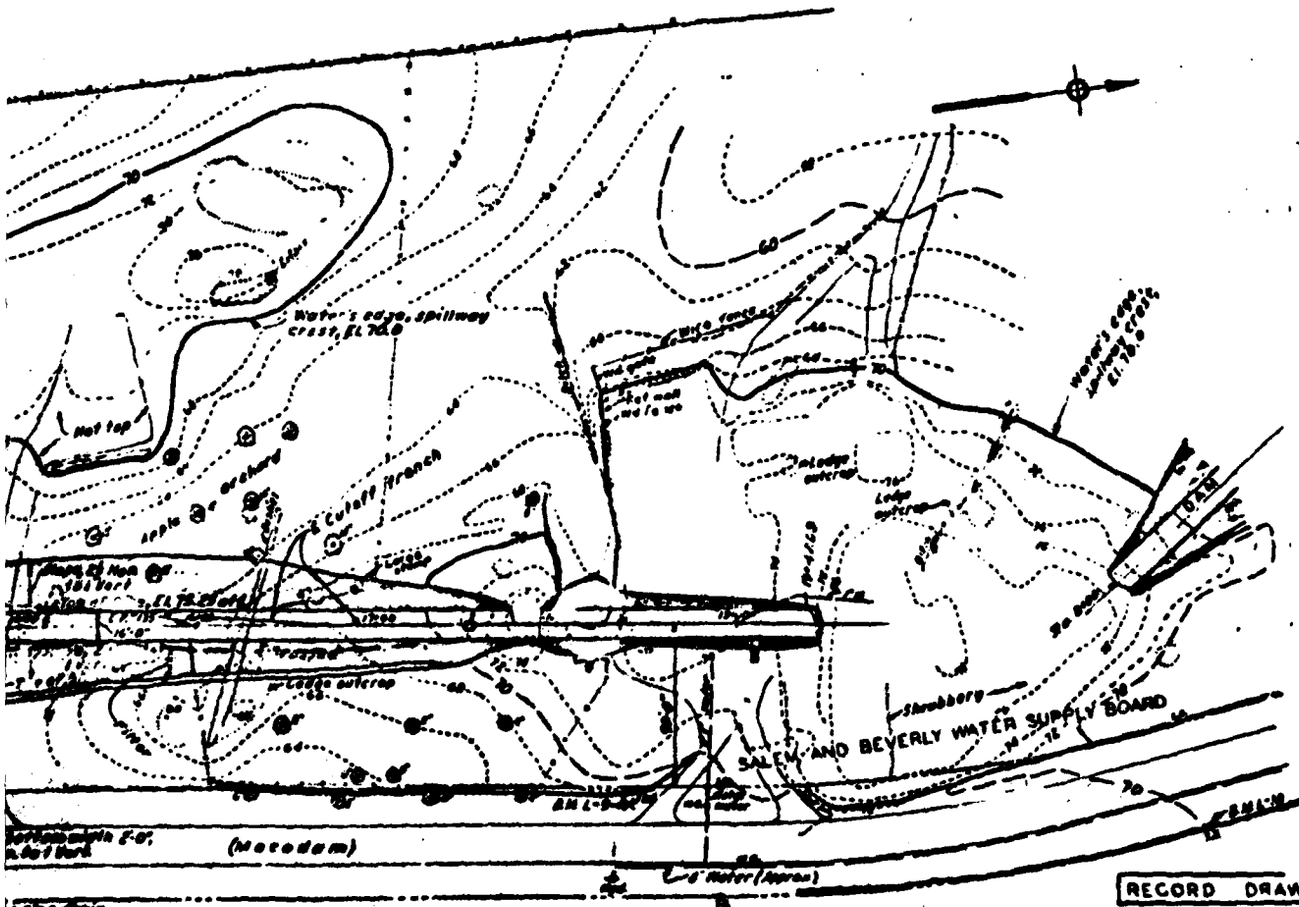

Top of Dike, El. 75.25 at ℄
Water surface, spillway cres
Present ground surface
Bottom of Cutoff Trench as Constructed
Ledge
Elevation in feet
Note: See Sheet 23 for "General Notes for all Borings, Bar Soundings and Test Pits"
Swamp
Water's edge, spillway crest, El. 70.0
℄ Cutoff trench
Riprap
Paved gutter
SALEM AND BEVERLY WATER SUPPLY BOARD


Top of Dike, El. 75.25 at E
Water surface, spillway crest, El. 70.0
Present ground surface
Lodge
Swamp
Swamp
Top of slope
Riprap
LOCUST
RECORD DRAWING
EAST DIKE
PLAN AND PROFILE - 1



Elevation in Feet
Ledge
Granite ledge
Water's edge, crest, El. 70.0
Note: See Sheet 2 for General Notes for all Borings, Bar Soundings and Test Pits.
Channel
Toe of slope
Riprap
Wooded
Apple orchard
Ledge outcrop
LOCUST
ST.
(Macadam)
Proposed 8" conc. pipe drain (See Sheet 8)
Limits of proposed random fill.





RECORD DRAWING

SALEM AND BEVERLY WATER SUPPLY BOARD
BEVERLY, MASS.

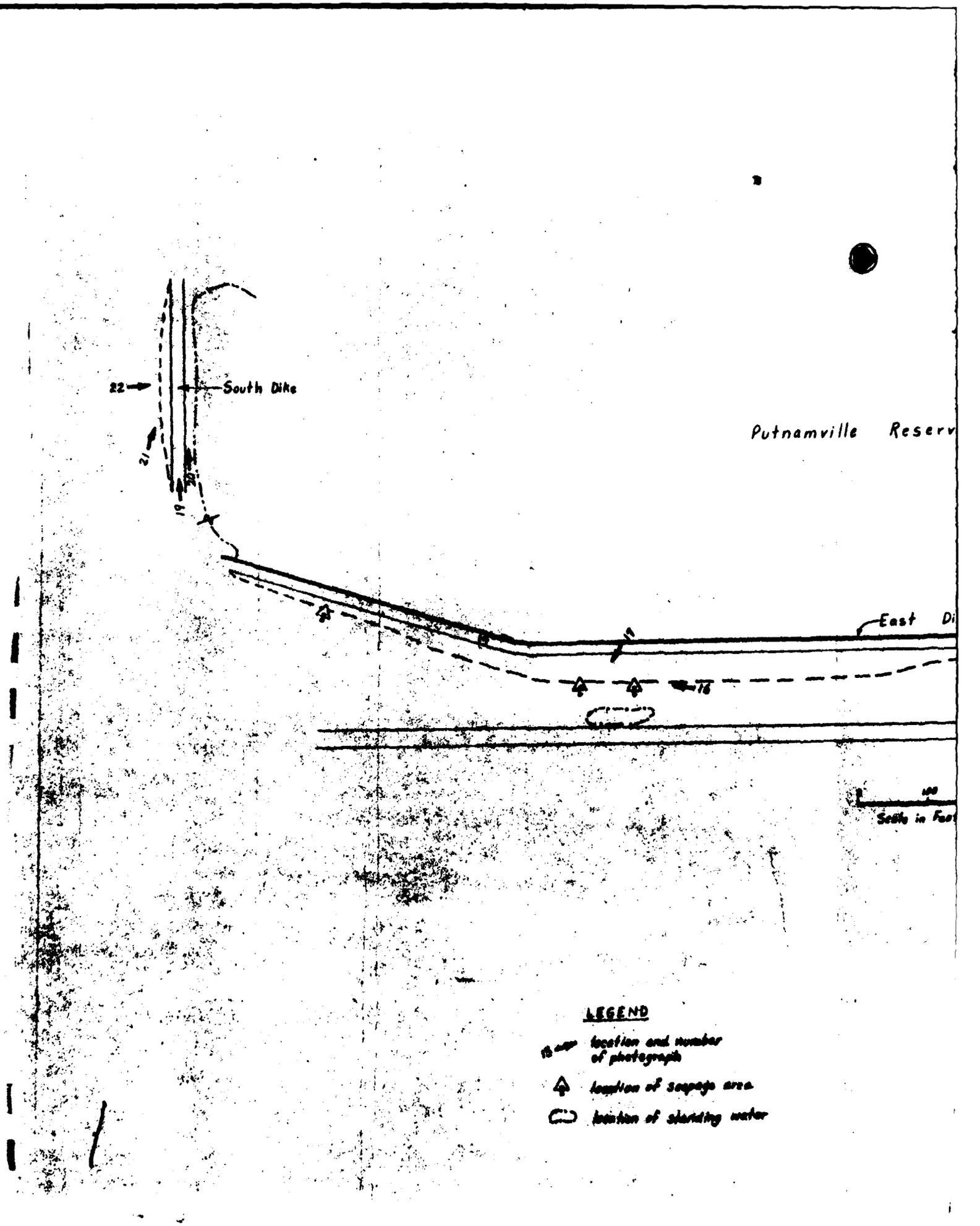
PUTNAMVILLE RESERVOIR PROJECT
RESERVOIR CONTRACT

EAST DIKE
PLAN AND PROFILE - 2

JUNE 1948

APPROVED

2


22
South Dike
21
19
Putnamville Reserv
East Di
16
100
Scale in Feet
LEGEND
location and number of photograph
location of seepage area
location of standing water

namville Reservoir

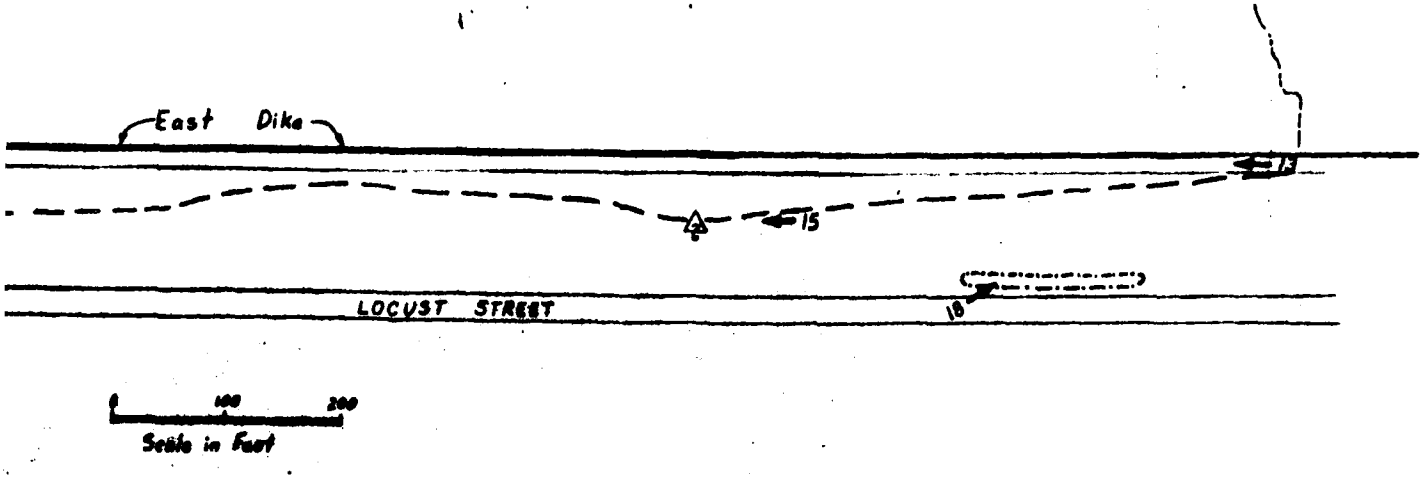
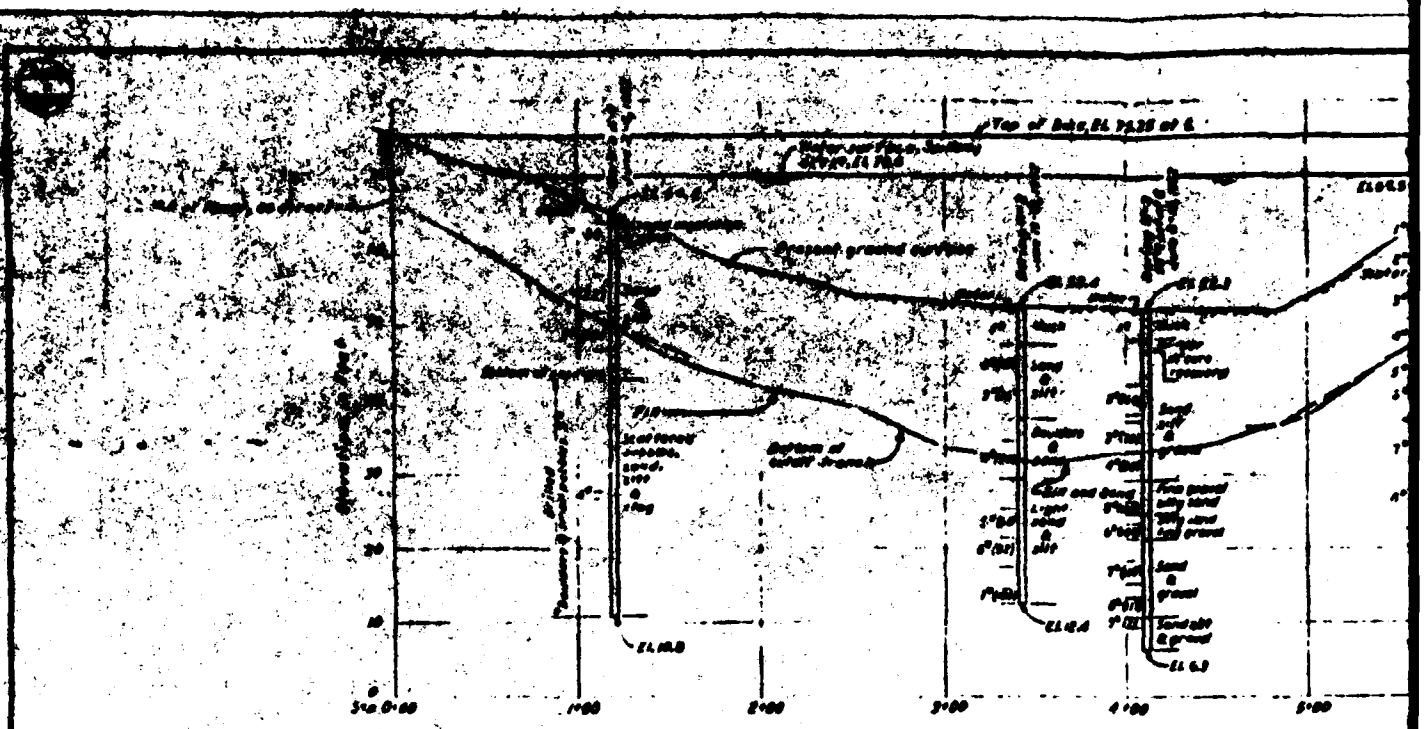


FIGURE B-4A

LOCATIONS OF PHOTOGRAPHS AND SEEPAGE AREAS

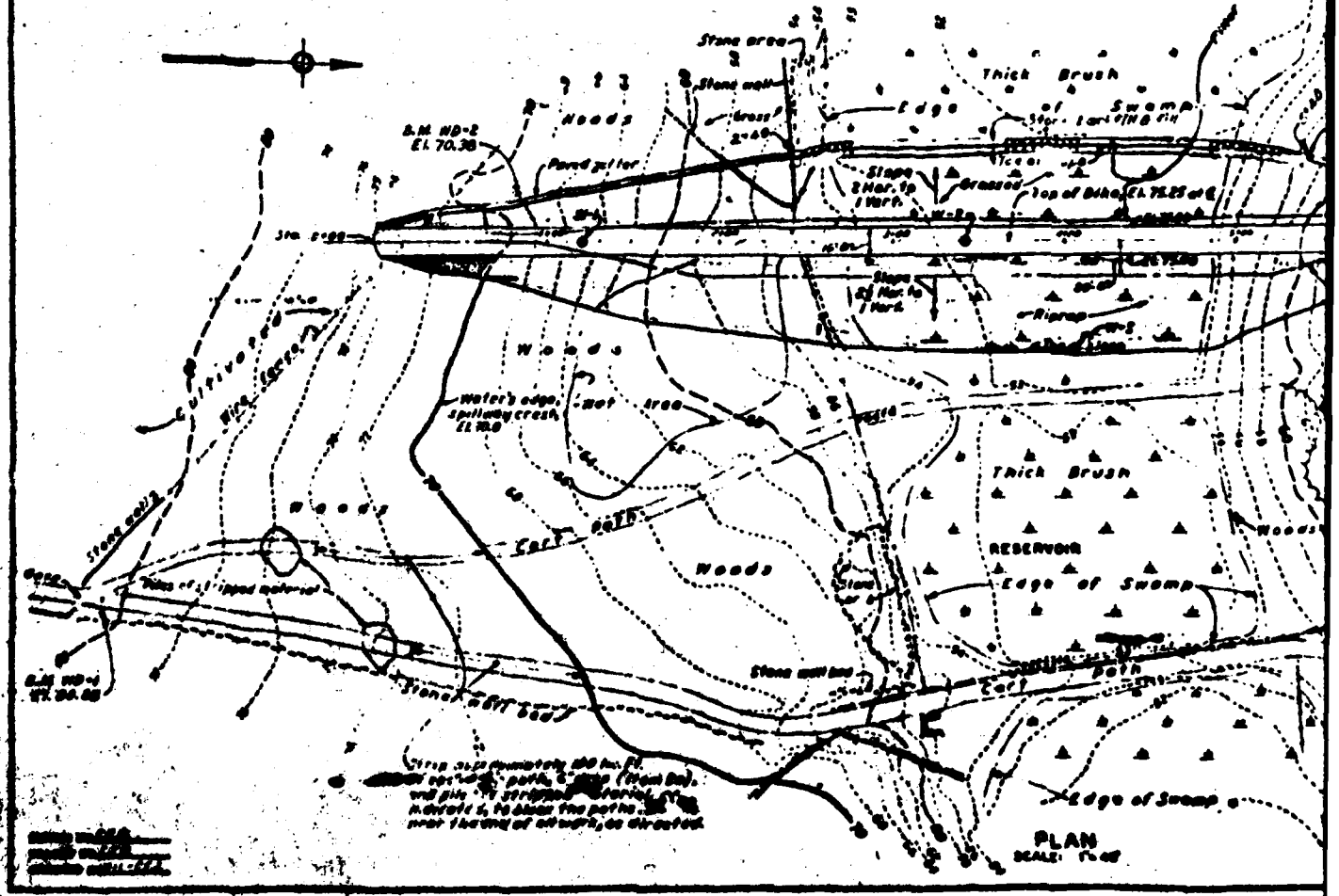
Putnamville Reservoir East Dike

2



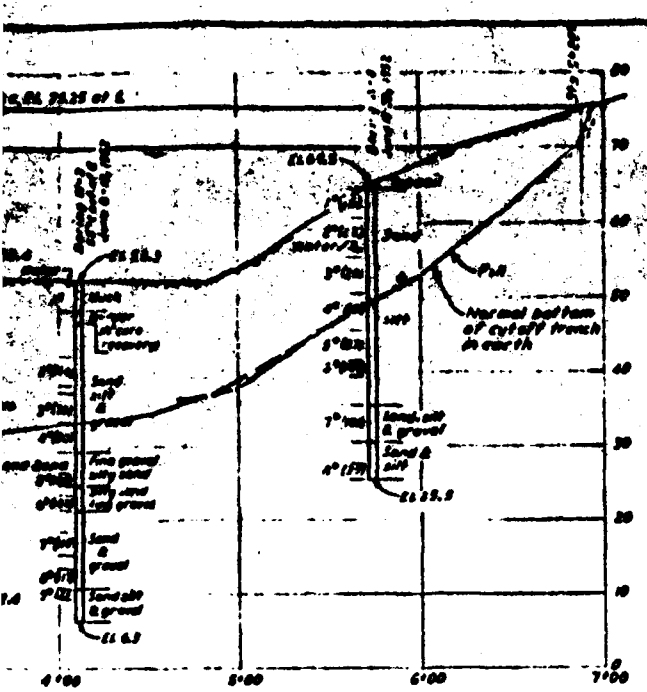
PROFILE ALONG CENTERLINE OF DIKE

SCALE HOR 1:40
VER 1:10



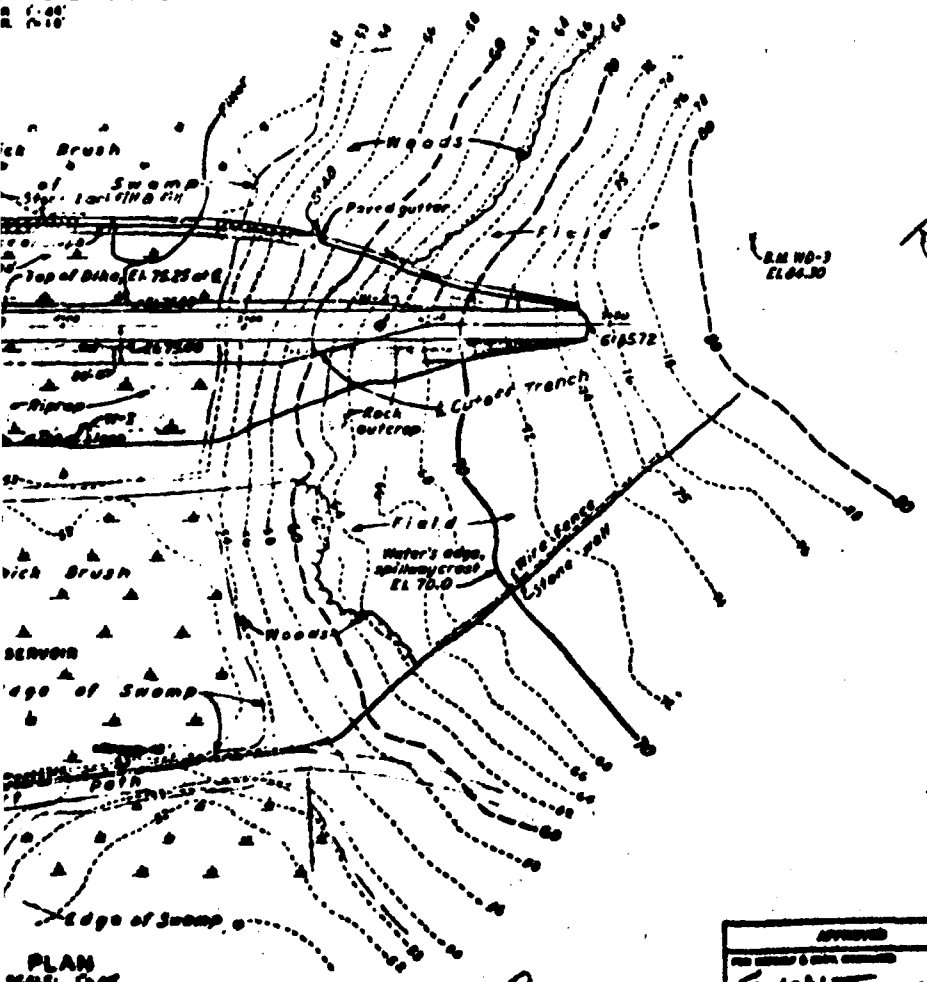
PLAN

SCALE: 1"=40'



Note: See Sheet 23 for General Notes for all Borings, Bar Soundings and Test Pits.

NTERLINE OF DIKE



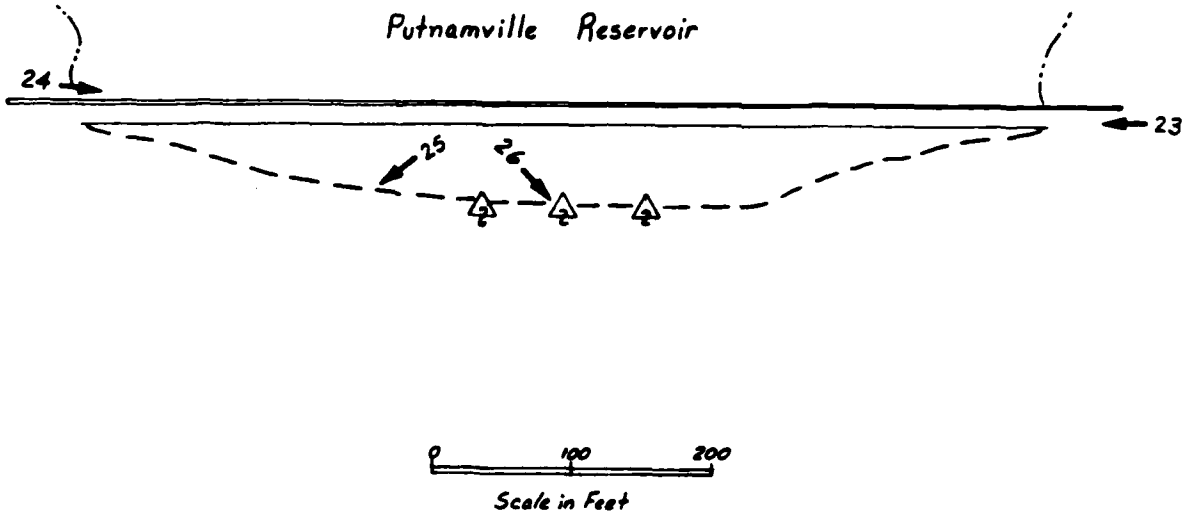
RECORD DRAWING

SALEM AND BEVERLY WATER SUPPLY BOARD
BEVERLY, MASS.

PUTNAMVILLE RESERVOIR PROJECT
RESERVOIR CONTRACT

WEST DIKE
PLAN AND PROFILE

DRAWING B-5



LEGEND

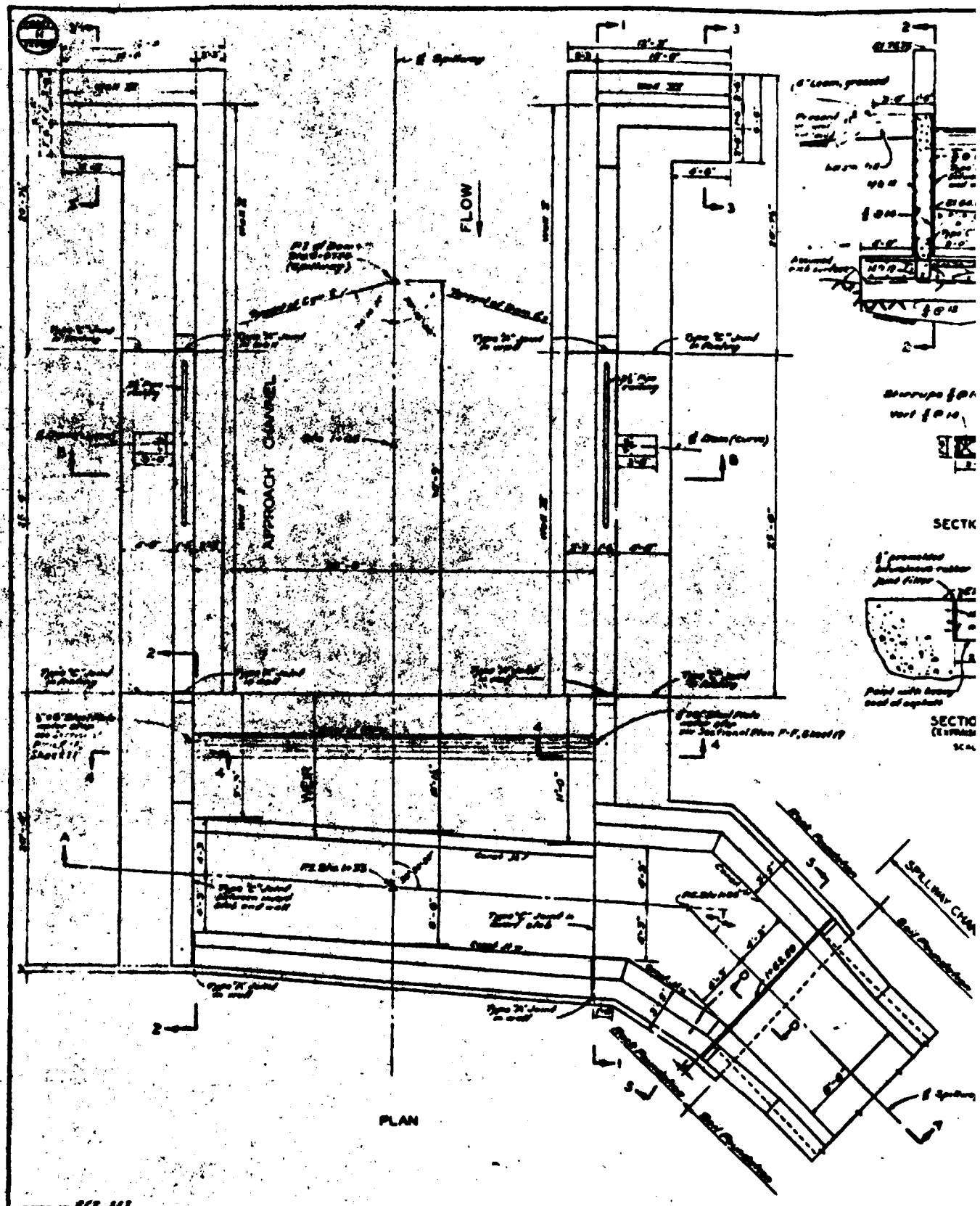
23 location and number of photograph

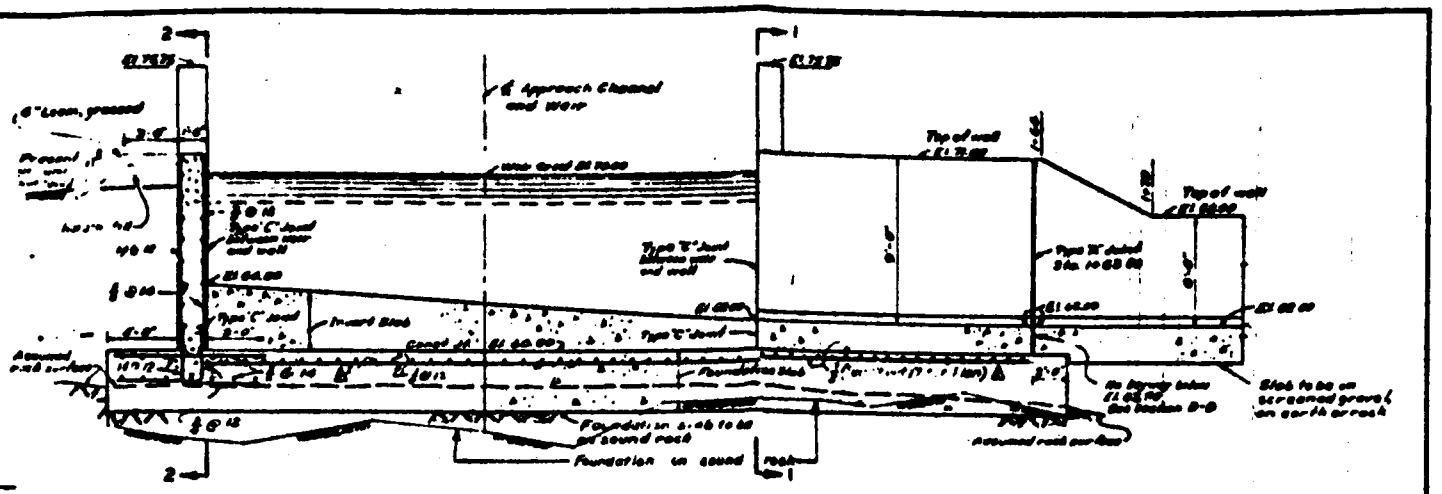
location of seepage area

FIGURE B-5A

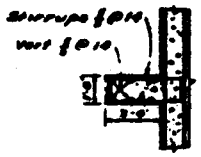
LOCATIONS OF PHOTOGRAPHS AND SEEPAGE AREAS

Putnamville Reservoir West Dike

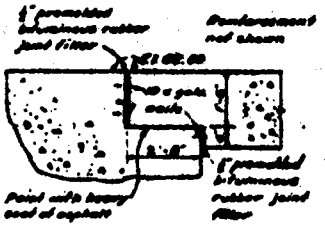

FLOW
APPROACH CHANNEL
WEIR
PLAN



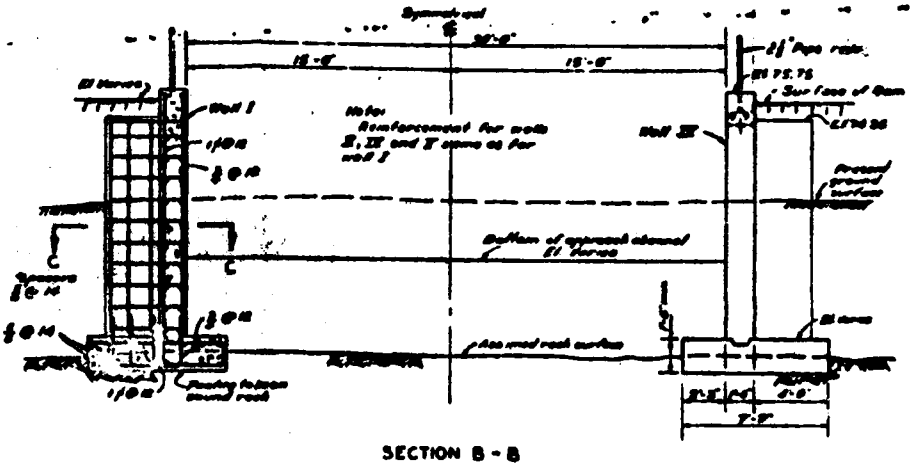
SECTION A-A



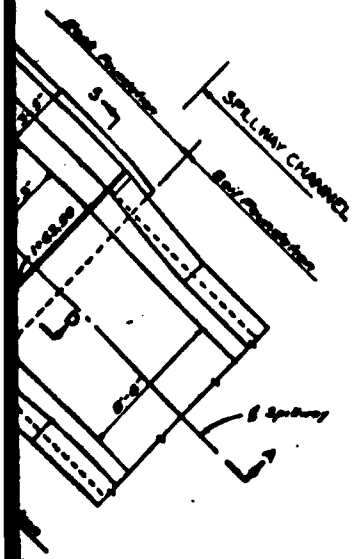
SECTION C-C

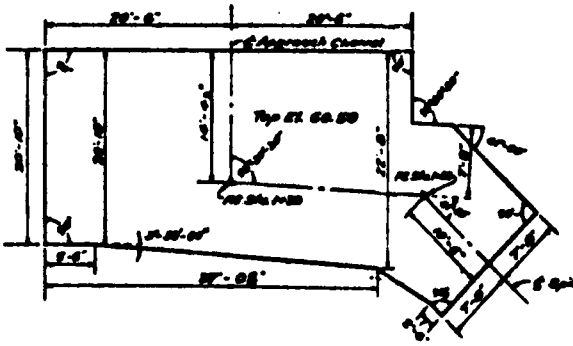


SECTION D-D
(EXPANSION JOINT)
SCALE 1/2"=1'-0"



SECTION B-B





PLAN OF FOUNDATION SLAB
SCALE: 1/4"=1'-0"

Notes:
1. See Sheet 11 for general notes applying to concrete work.
2. See Sheet 17 for Sections 1-1 to 8-8, inclusive, and outline of weir.
3. Backfill and fill all areas beneath and within normal limits of dam with same type of material as required for corresponding areas of dam (see sheet 3).

RECORD DRAWING

Revised	Checked	Approved	Date
Revised	Checked by	Description	

SALEM AND BEVERLY WATER SUPPLY BOARD
BEVERLY, MASS.

PUTNAMVILLE RESERVOIR PROJECT
RESERVOIR CONTRACT

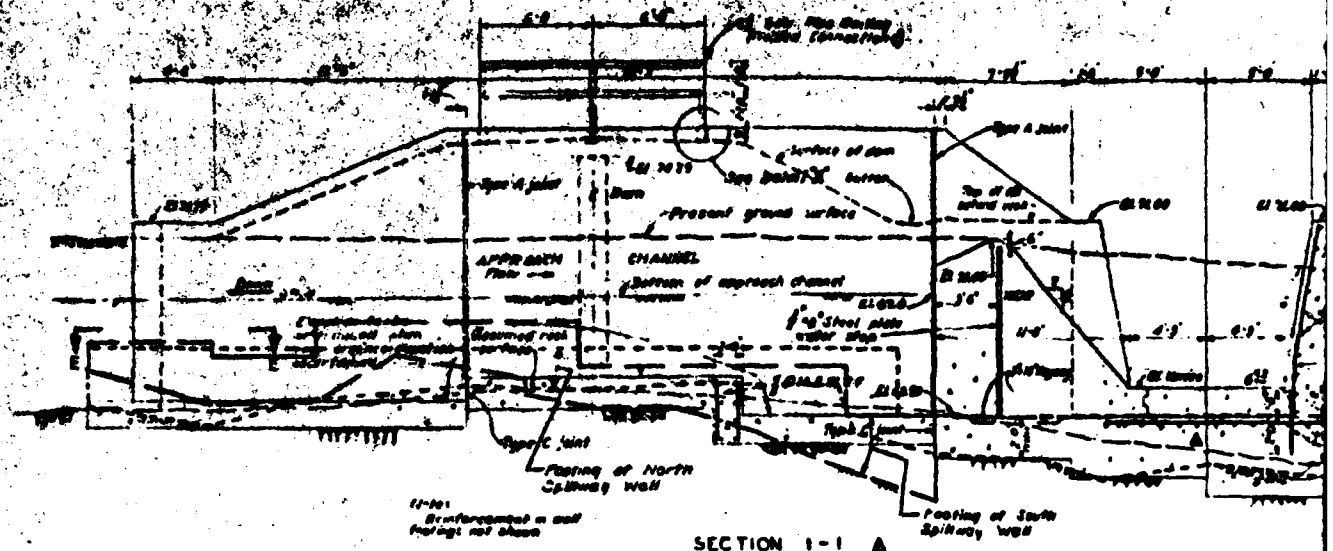
SPILLWAY - 1

SCALE 1/4"=1'-0"
SHEET 16 OF

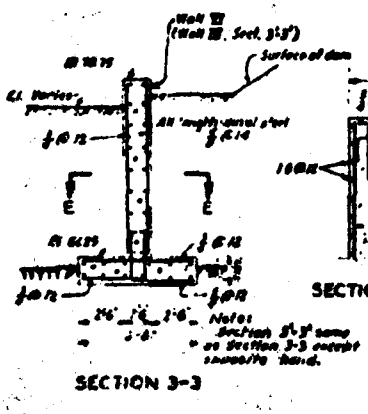
METCALF & EDDY
ENGINEERS
BOSTON, MASS.

APPROVED
FOR SALEM & BEVERLY WATER SUPPLY BOARD
Chief Engineer
Date

FIGURE D-6 CONTRACT 1 SHEET 16 OF

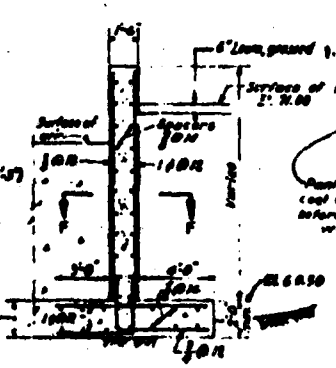


SECTION 1-1 A

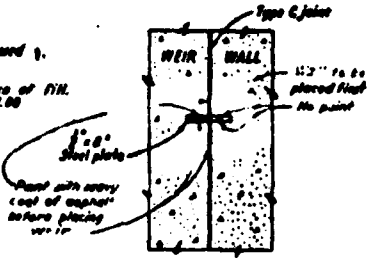


SECTIONAL PLAN E-E

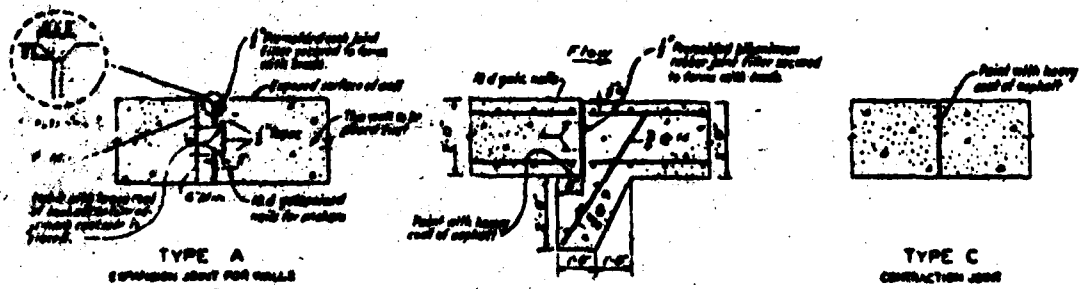
SECTION 3-3



SECTION 4-4



SECTIONAL PLAN F-F



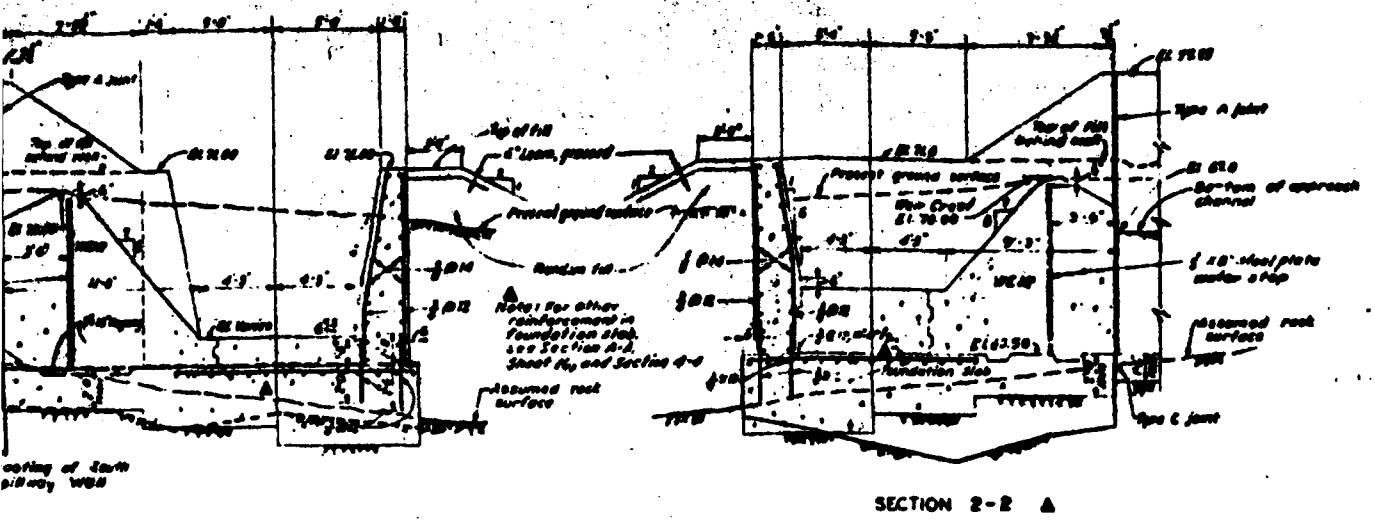
TYPE A
EXPANSION JOINT FOR WALLS

TYPE B
EXPANSION JOINT FOR SLABS

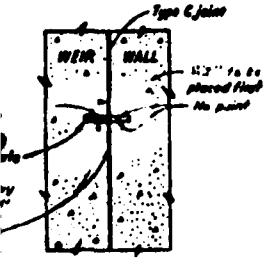
TYPE C
CONTRACTION JOINT

DETAIL "X"

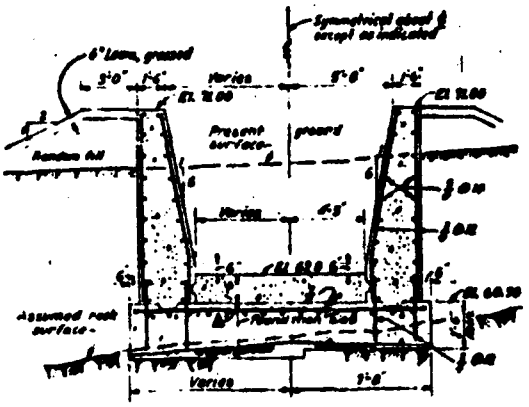
DETAILS AT EXPANSION AND CONTRACTION JOINTS



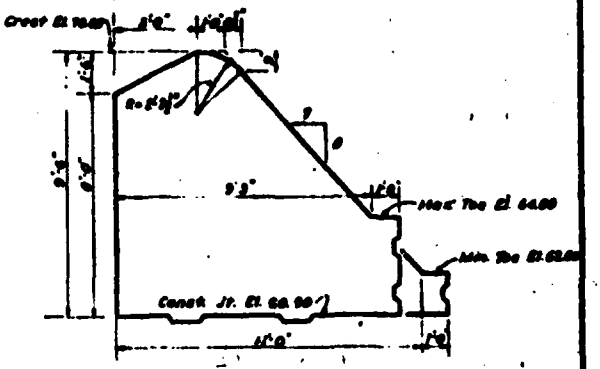
SECTION 2-2



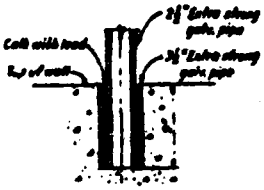
SECTIONAL PLAN P-P



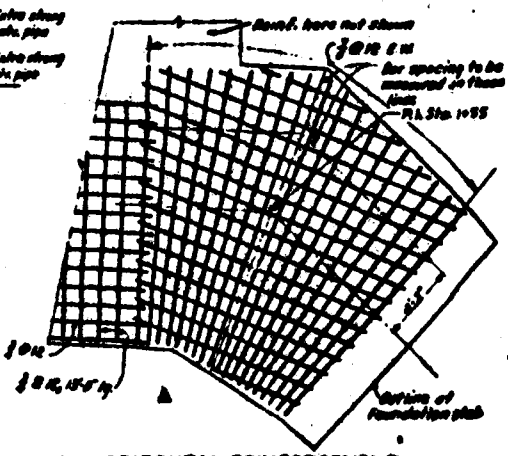
SECTION 3-3



OUTLINE OF WEIR



DETAIL "X"



PLAN OF HORIZONTAL REINFORCEMENT IN FOUNDATION SLAB

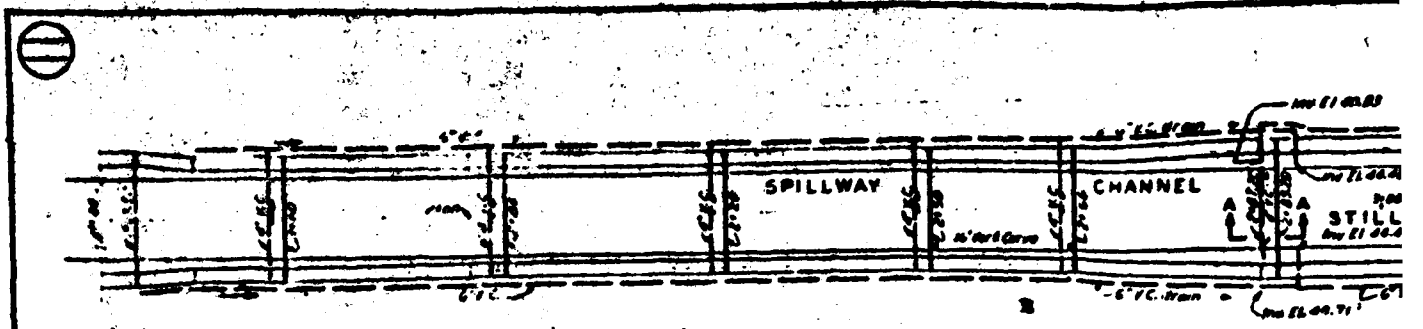
RECORD DRAWING

SALEM AND BEVERLY WATER SUPPLY BOARD
BEVERLY, MASS.

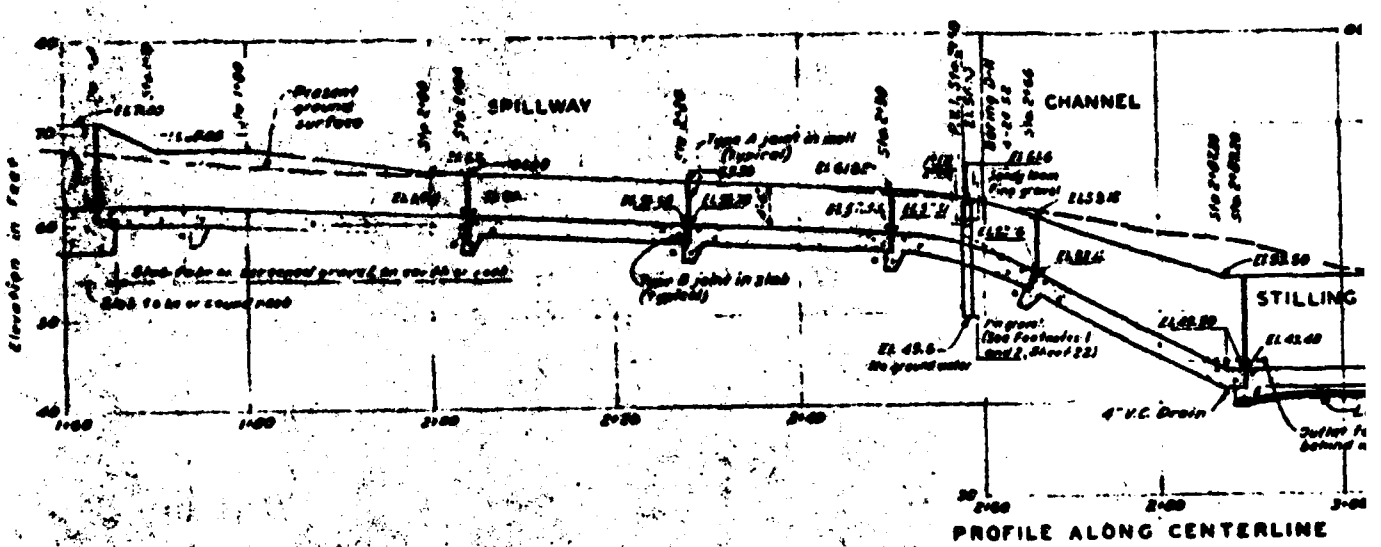
PUTNAMVILLE RESERVOIR PROJECT
RESERVOIR CONTRACT

SPILLWAY - 2

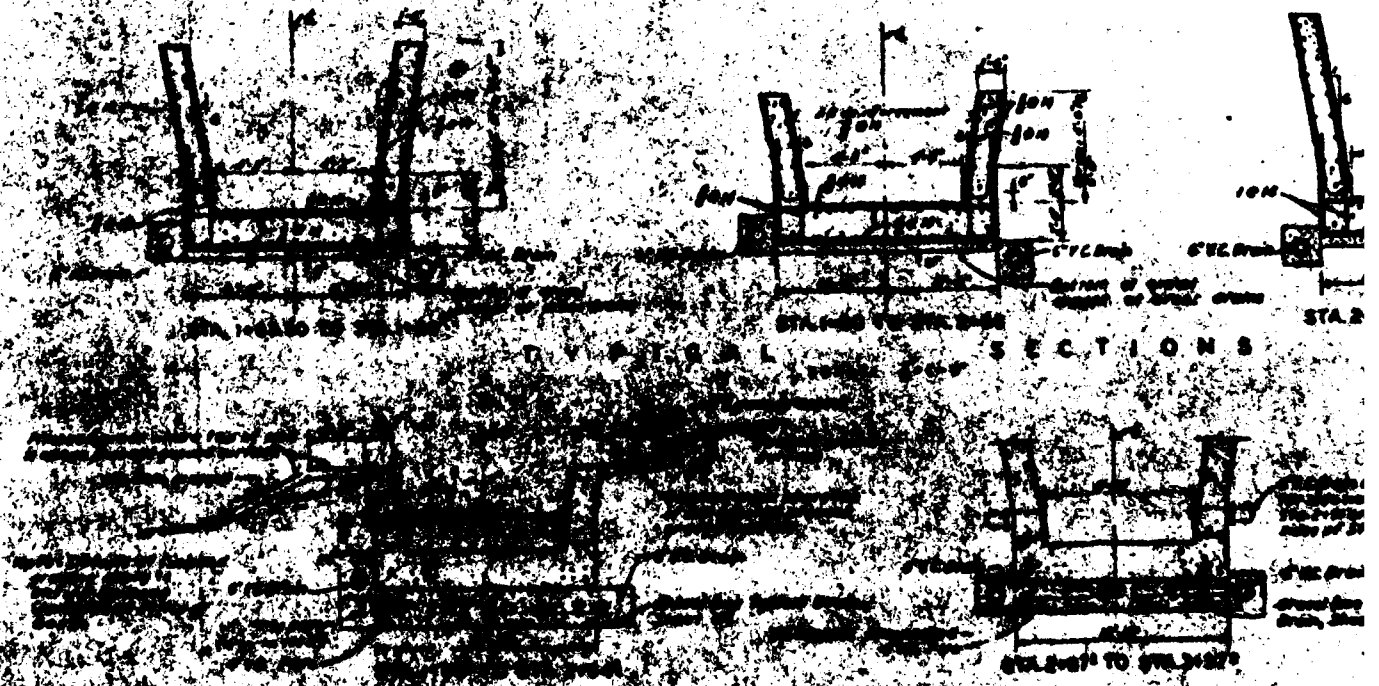
FIGURE 2-7



PLAN

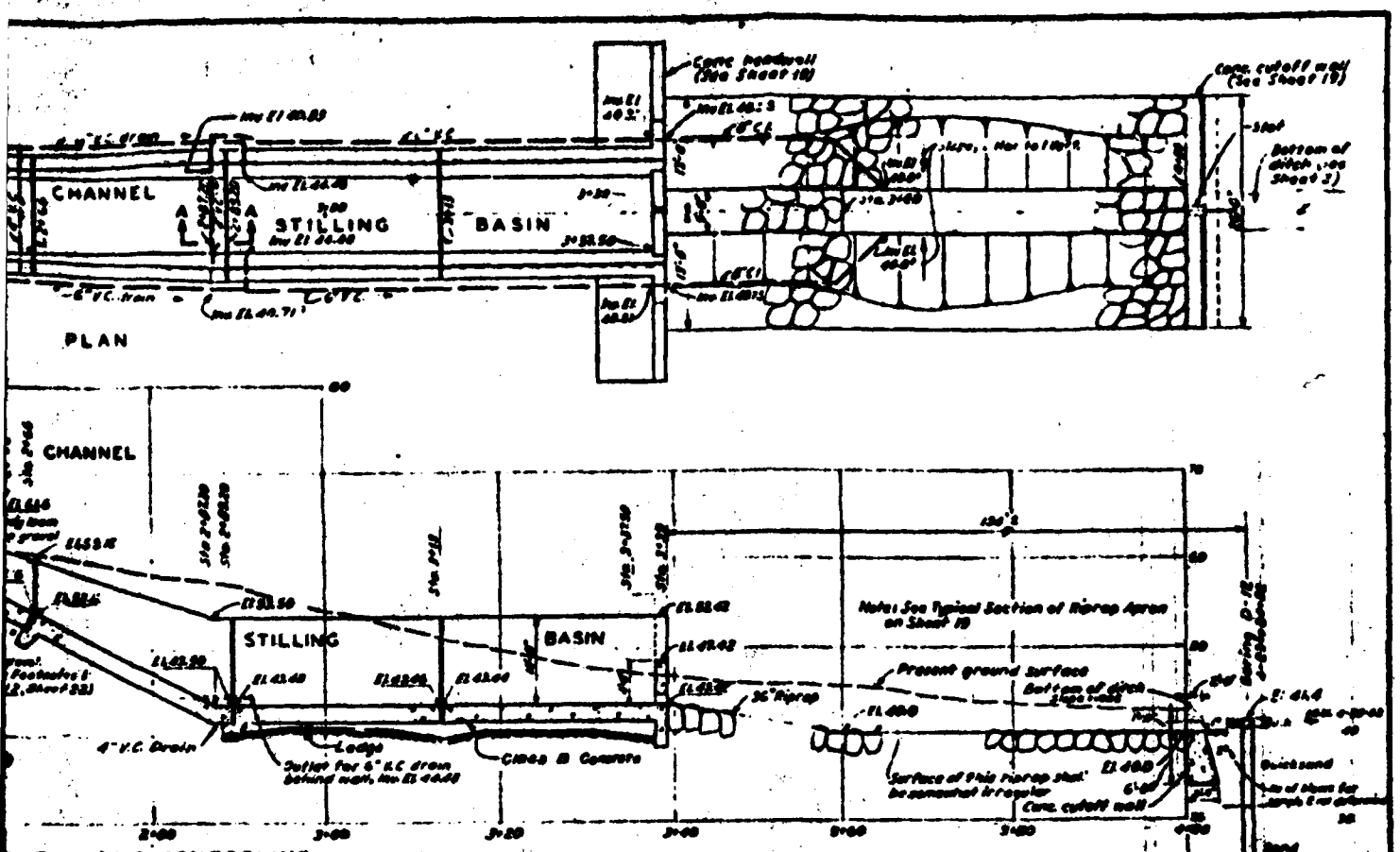


PROFILE ALONG CENTERLINE



TYPICAL SECTIONS

TYPICAL CROSS DRAINS AND GRADING



ILE ALONG CENTERLINE

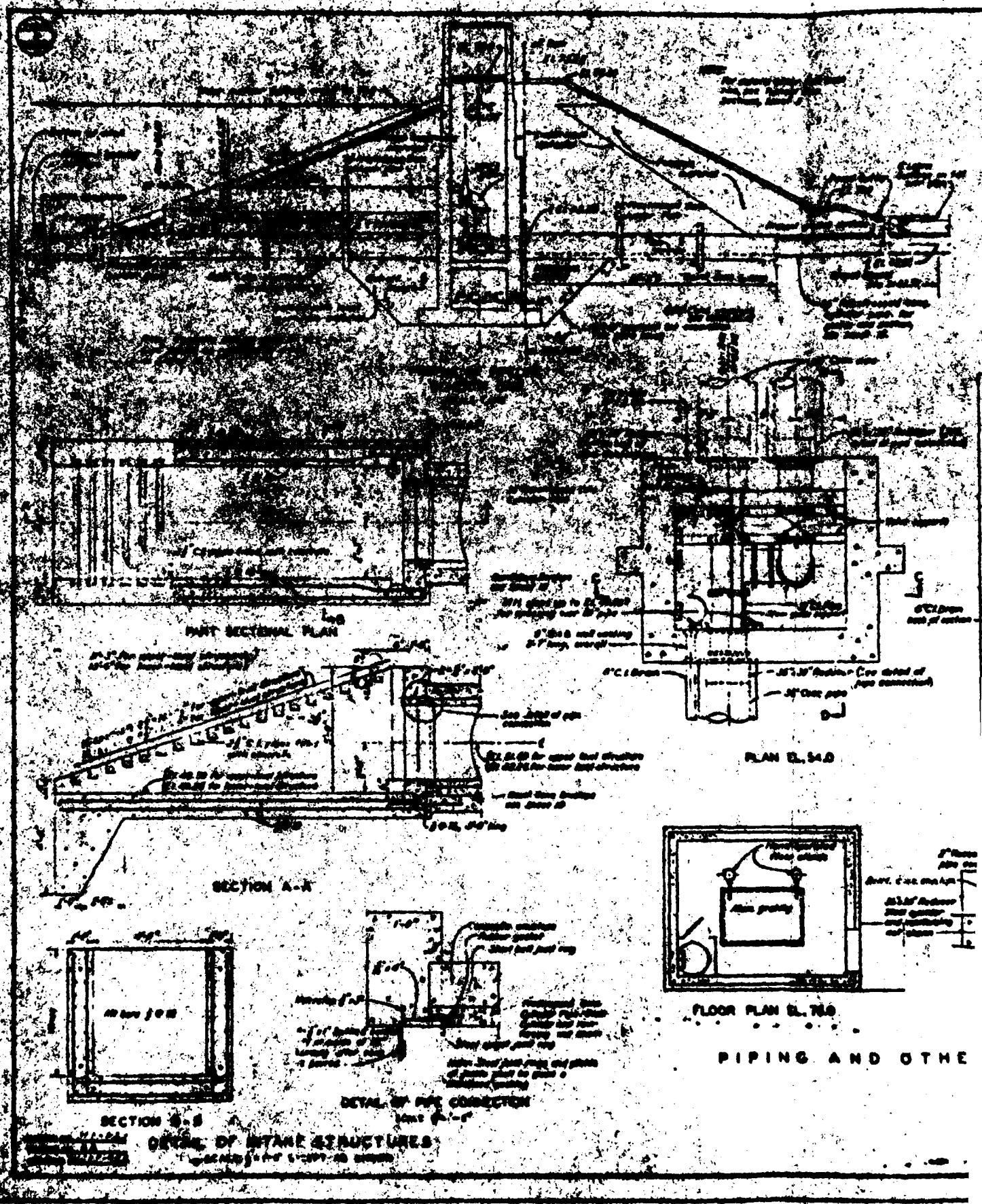
SECTION A-A

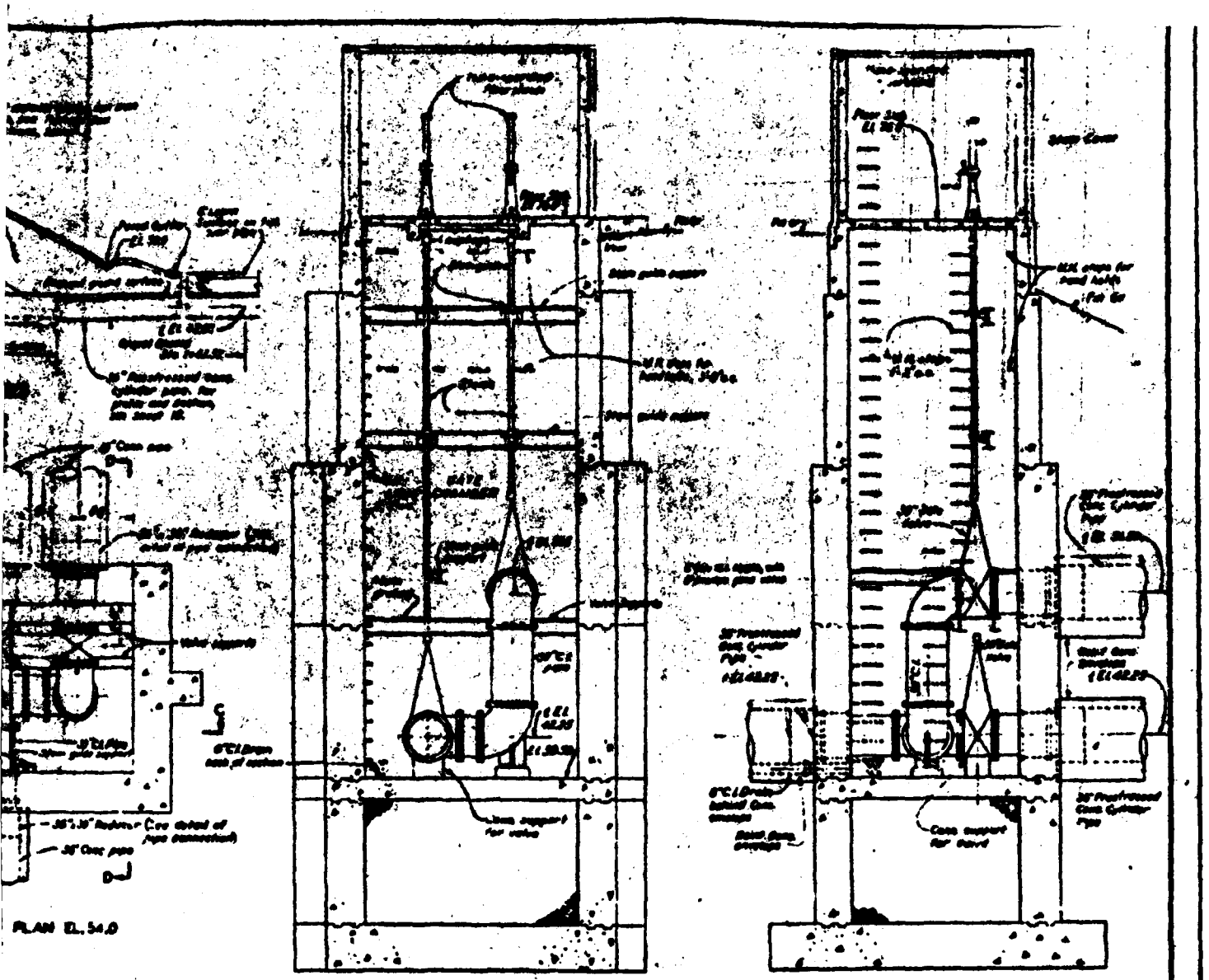
STA. 2+88 TO STA. 3+27.5

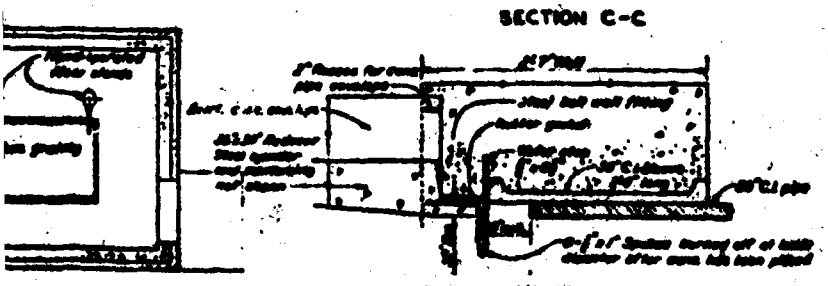
ECTIONS

RECORD DRAWING

SPILLWAY - 3


PART SECTIONAL PLAN
PLAN EL. 14.0
SECTION A-A
FLOOR PLAN EL. 7.0
SECTION B-B
DETAIL OF PIPE CONNECTION
PIPING AND OTHE
DESIGN OF INTAKE STRUCTURES





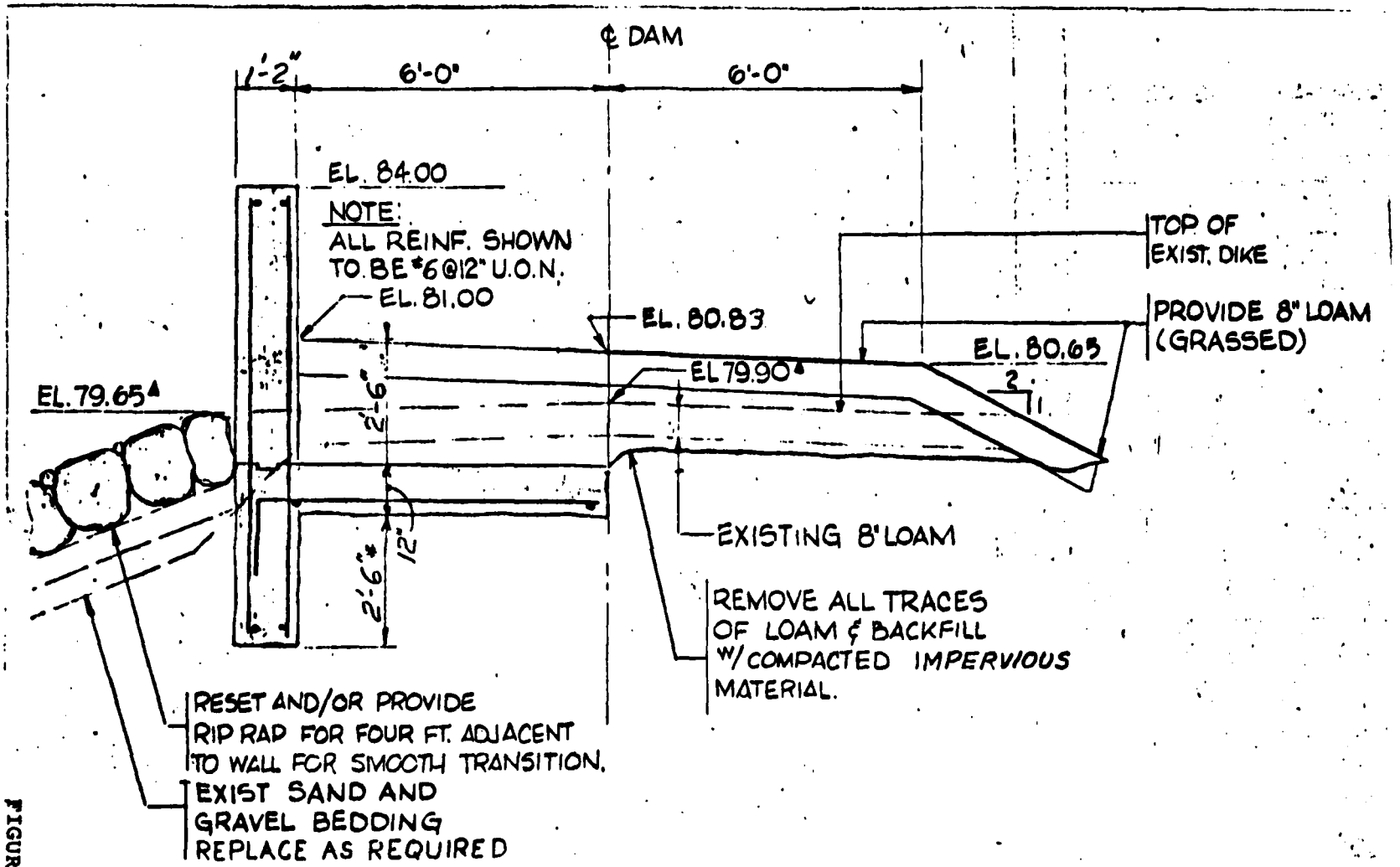
PING AND OTHER DETAILS AT GATE HOUSE

RECORD DRAWING

SALEM AND BEVERLY WATER SUPPLY BOARD
BEVERLY, MASS.

PUTNAMVILLE RESERVOIR PROJECT
RESERVOIR CONTRACT

GATEHOUSE AND OUTLET WORKS
MISCELLANEOUS DETAILS - 1



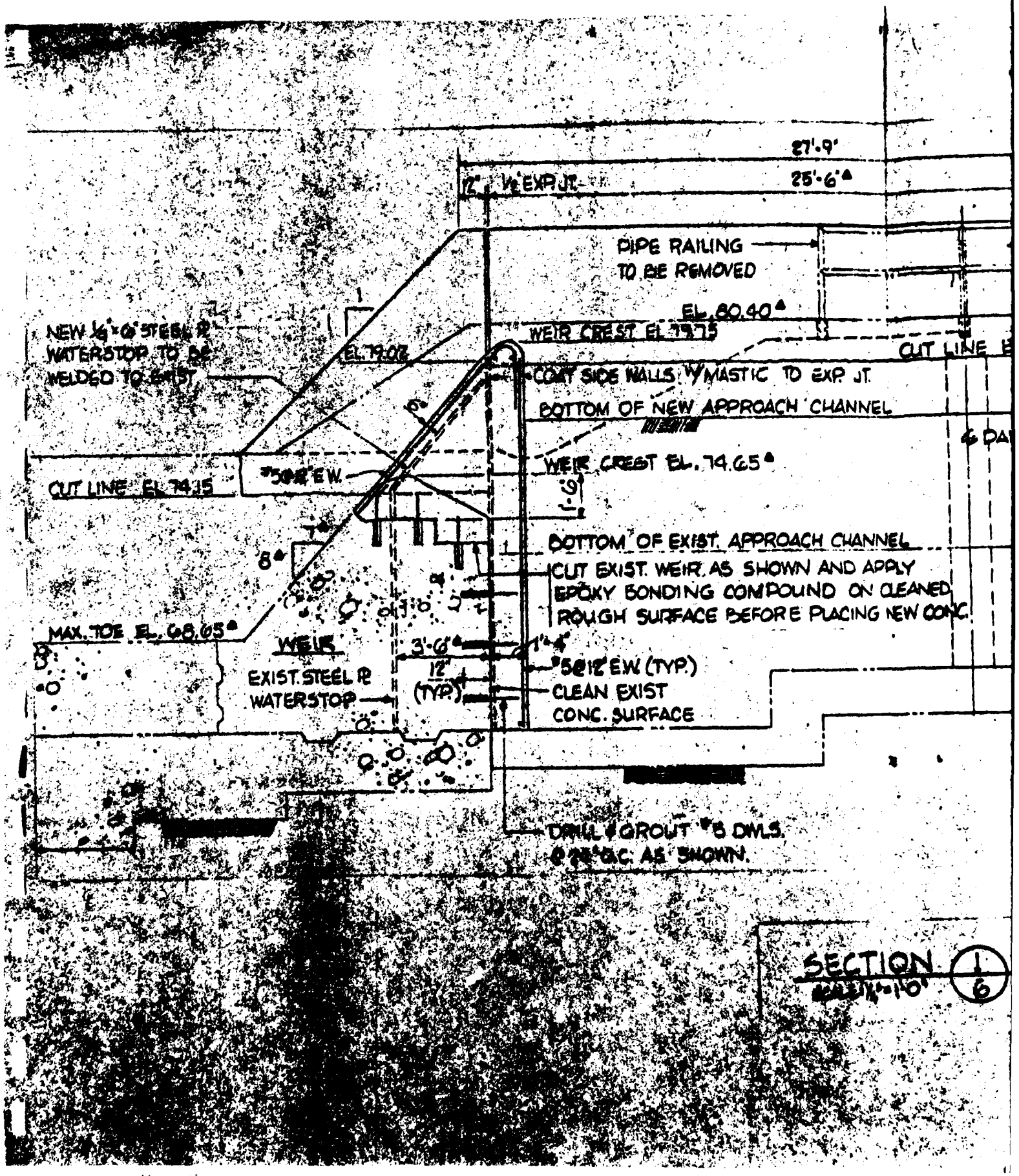
PARAPET WALL SECTION
(TYPICAL FOR EXISTING DAM & DIKES)

SCALE : 3/8"=1'-0"

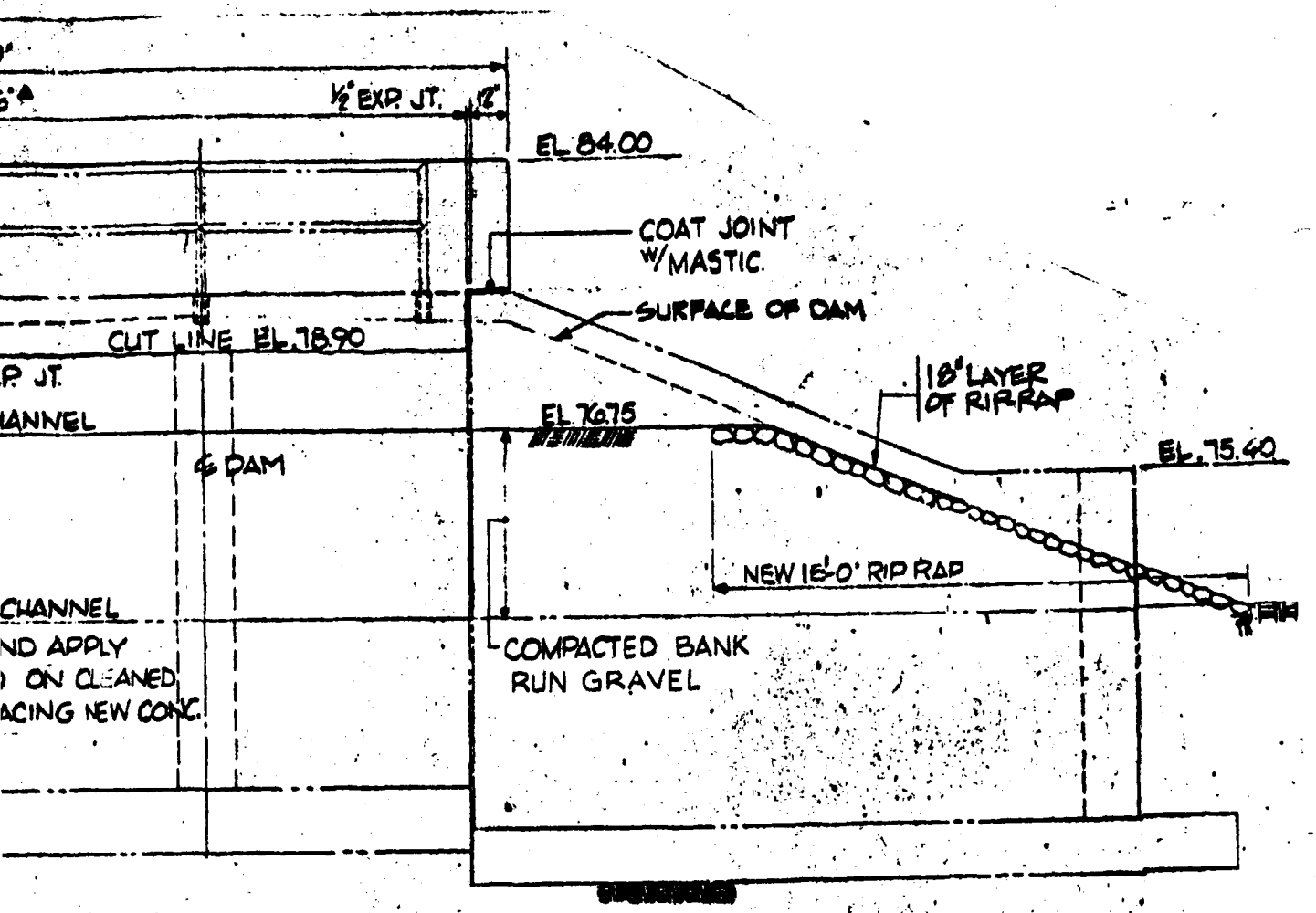
EXCERPT FROM SHEET 5
SECTIONS

Record Drawings dated 1979
by Camp, Dresser, and McKee, Inc.

FIGURE B-10
PUTNAMVILLE RESERVOIR
DAM AND DIKES



SECTION 1/6
SCALE ½"=1'-0"



CTION 1/6
1'-0"

EXCERPT FROM SHEET 6
SPILLWAY MODIFICATIONS

Record Drawings dated 1977
by Camp, Dresser, and McKee, Inc.

Part "B" (continued)

Note * denotes figure based on 100 yr storm. When reservoir is at normal pool elevation and pumping into reservoir is continued 25 mgd rate.

DESIGN CRITERIA

1. Datum used:
   (a) M.S.L. of 1929 X.
   (b) Assumed _____.
   (c) Other _____.

2. Maximum height of the dam 38 ft.
   (a) Top elevation of dam 84.00.
   (b) Top elevation of spillway 79.75.

3. Volume of water impounded, at maximum design pool level. 2380 MG gallons

4. Present river bed or channel elevation @ dam 46.00.

5. Normal pool elev. 79.75.
   surface area 290 ac.

6. Maximum pool elev. 80.55*.
   surface area 295* ac.

7. Type of structure (earth, concrete, etc)
   Earthen (exist) with (new) concrete parapet and one (new) Earthen Dike

8. Crest width Twelve ft.

9. Freeboard, as measured from the maximum design pool level 3.45 feet*.

10. Length of Principal spillway 30 feet.

11. Description of principal spillway Ogee crest, side chanpel spillway with stilling basin.

12. Emergency spillway Yes ( ) No (X)
    If yes, describe _____.

13. Gates Yes (X) No ( ) Number 2. Size 30" Gate Valves on 36" fill & drain pipeline

14. Nature of slope protection (riprap, vegetated etc.) Rip-Rap.

15. Stop log structure(s)
    Yes ( ) No (X) Mechanical ( ) Manual ( )

EARTH EMBANKMENT

Items 5a to 5e, inclusive

Section 5.1 General. Under Items 5a to 5e, inclusive, the Contractor shall place in the dam and dikes, and elsewhere if required, rolled embankment, including impervious and pervious materials; shall furnish pervious material from private sources, if directed, and shall make random fills.

As indicated on the drawings, the major sections of the dam and dikes shall be constructed of impervious material, placing the most impervious and most suitable fine material near the center and upstream side of the dam and dikes, and grading to the pervious section near the downstream face of the dam and dikes. Carefully selected and graded material from the excavations and from approved borrowpits shall be used in the embankment. The materials to be used, the moisture content on compaction, and the rolling necessary to attain the degree of compaction required in the various portions of the embankment, shall be as directed from time to time by the Engineer. The Contractor shall furnish all equipment, plant, and labor required to obtain and transport the materials, control their moisture content, and thoroughly compact them in place, and shall cooperate to the fullest extent in utilizing the available material to the best advantage. All excavation, transportation, and placing operations shall be such as will produce a satisfactory mixture and gradation of the materials after they have been spread and compacted.

Section 5.2 Preparation of Embankment Foundation. No material shall be placed in any section of the earth-fill portion of the dam or dike embankment until the foundation for that section has been unwatered and suitably prepared and has been approved by the Engineer. Rock or similar solid surfaces upon or against which material for the impervious section is to be placed shall be cleaned by handwork or other effective means satisfactory to the Engineer, of all loose and rotten rock and other objectionable materials. The surfaces of each portion of the rock foundation immediately prior to receiving any material for the earth fill, shall have all water removed from depressions, and shall be sufficiently clean to obtain a suitable bond with the embankment.

Immediately prior to the placing of material in the embankment of the dam and dike, the stripped earth foundation and the surface of refilled material at trenches shall be plowed, harrowed, or otherwise scarified as directed to a depth of approximately 6 in. and then compacted as though it were new material, as hereinafter specified, so that the first layer of the embankment will be firmly bonded to the foundation.

If springs develop on the surface after stripping within the limits of the dam or dike, they shall be controlled by plugging, draining, or other approved methods. Materials used or excavations made for such control shall be paid for under the appropriate items as determined by the Engineer, but no other

direct payment shall be made for the preparation of foundations as herein specified, it being agreed that compensation therefor shall be included in the prices stipulated for the items of excavation and embankment.

Section 5.1 Materials. Rolled embankment for the dam and dikes shall consist of suitable materials from the excavations made for other parts of the work or from borrowpits. The relative fineness of the material to be placed in each portion of the embankment and the approximate limits of each such portion shall be as ordered by the Engineer. Any load of the material to be placed in the embankment, whether from excavation for other parts of the work or from borrowpits, may be ordered to be placed in a location designated by the Engineer, regardless of the classification of the excavation, and the Contractor shall be entitled to no additional allowance above the contract unit prices for excavations and embankment, due to the requirement. The completed embankment shall be free from lenses, pockets, streaks, or layers of material differing materially in permeability from the surrounding material, and to this end, every effort shall be made in the borrowpits to mix the materials for the impervious embankment as thoroughly as possible. In the borrowpits, such materials shall be loaded by power-driven shovels which shall, as may be necessary or required, be operated as mixers with open dippers. Other loading devices may be approved, provided the mixing produced is as efficient as that of the shovel mixing above specified.

The Engineer may designate the depths of cut in all parts of the borrowpits or in other excavations of material to be used in the earth fill, necessary for obtaining the desired gradation of material, and the cuts shall be made to such designated depths. Each load of earth-fill material delivered on the earth fill shall be the equivalent of a mixture of materials obtained from an approximately uniform strip or cutting from the full height of the face of the excavation. If necessary, additional mixing shall be done by disc harrowing or other approved method after the material has been spread on the embankment.

The material in the downstream section shown as pervious shall be free-draining sand and gravel containing less than 5 percent of material which will pass a 200-mesh sieve.

All stones larger than those which will pass through a 6-in. square opening shall be removed from the material, before it is brought onto the embankment, by passing through an approved grizzly or by other approved methods. The stones removed may be used for chinking riprap or may be disposed of otherwise, as directed. In the embankment, accumulation in groups or nests of stones remaining in the material, particularly stones of the larger sizes, shall be kept to the practical minimum.

The borrowpits shall, in general, be opened from end to end so as to enable selection to be made both for quality of material and moisture content, and as may be necessary, their top surfaces after stripping shall be graded, rolled, or otherwise treated so as to shed rain water.

No brush, roots, sod, or other perishable or unsuitable materials shall be placed in the embankment. Materials unsuitable for embankment of any class will be rejected and shall be disposed of as directed.

No frozen material nor recently thawed material shall at any time be used in the construction of the rolled embankment, and no material shall be placed on portions of such embankment which are frozen or which have been loosened by freezing. Upon the resumption of work after freezing weather, the surface of the embankment shall be prepared as specified in Section 5.2 or as directed by the Engineer.

Section 5.4 Transportation. Materials for the construction of embankment shall be transported on the dam or dikes in approved conveying units of such size and having such ample bearing-tread areas that the completed fill will not be rutted by their passage. Conveying equipment shall not be permitted to follow tracks on the dam or dike, and the routes of travel shall be varied and spread out and, where ordered, ruts on the embankment shall be promptly filled and leveled off. Unless otherwise permitted, the total weight, including its load, of any truck or conveying unit shall not exceed 30 tons or have a tire-contact pressure in excess of 65 psi., the purpose of this limitation being to prevent nonuniform consolidation of the embankment. Heavier equipment may be used if it be shown that it will not cause nonuniform consolidation.

Section 5.5 Placing and Spreading. Just prior to placing of a new layer of impervious embankment, the surface of the preceding layer shall be scarified to a depth of 2 in. with a suitably rugged harrow or other approved equipment so that an effective bond will be obtained between layers.

All embankment material shall be evenly and uniformly spread in layers as nearly as practicable 7 in. in uncompacted thickness. Arriving material shall be dumped in rows adjacent to each other and parallel to the axis of the dam or dike, so that the spreading and rolling equipment will travel parallel to that axis. Only lightweight spreading equipment, sprinkling trucks, and harrows as necessary shall be permitted to pass over any layer that is being, or has been, prepared for rolling until after the rolling of that layer has been completed. Joints and laps in, or between, layers shall be carefully made so as to ensure the continuity of each layer in all directions. Each layer shall be thoroughly compacted to the extent required, before a new layer is placed.

All impervious embankment surfaces over which hauling has been done shall be harrowed or scarified to the depth directed and recompacted as required, at the Contractor's expense, before any new layer is placed.

A sufficient number of men shall be available at all times as the spreading and rolling are being done to remove all oversize stones, roots, and other unsuitable materials and to separate the smaller stones.

Section 5.6 Moisture Content and Control. It is the intention to obtain in the completed impervious embankment, a degree of compaction such that the maximum dry density will be secured within the practical limits of the best construction practice. In the pervious embankment, the compaction shall be such as to obtain the density necessary to resist shearing movement and ensure permanent stability. To this end, all methods and procedure must be carefully guarded and controlled.

The moisture content shall be as prescribed by the Engineer and shall be as nearly as practicable that percentage, by weight, of water in the material which will permit compaction in the embankment to not less than 97 percent of the maximum density obtainable with the specified rolling equipment. Dry weight of a unit volume of the material will be used in determining the density. Changes in the prescribed moisture content may be made from time to time to conform to changes in the character and grading of the material.

The control of moisture may be required in the borrowpits, as well as on the embankment. When the material is too dry, sprinkling or other means of wetting uniformly may be required. When the material is too wet, ditches, pumps, drainage wells, or other devices may be required in the borrowpits, and the exposure of the greatest possible area to the sun and air in conjunction with harrowing, plowing, spreading of the material, or any other effective method which will reduce the moisture content may be employed.

The placing or rolling of material on the impervious embankment will not be permitted whenever rainstorms are imminent or during or immediately after rainfalls or when any other weather condition prevails which would increase the moisture content beyond the limit at which satisfactory compaction can be obtained.

The embankment shall be brought up uniformly, and its top shall be graded and sloped perpendicularly to the axis of the dam or dike and not over 2 percent, so that a minimum of rain water will be retained thereon. The top of the embankment shall be kept free from holes and depressions, and all such as may be formed by any cause shall be promptly leveled off as directed by the Engineer. Pools of water from any sources shall be promptly emptied and the holes filled with dry material.

Whenever any portion of the impervious embankment is to stand for two weeks or longer, during which period no additional layers of material are to be placed, or whenever rainstorms are imminent, the embankment shall, if so ordered, be smooth-rolled so as to shed water readily. Such smooth-rolling shall not be included in the count of roller trips herein specified or as additional rolling. Before work is resumed, the surface shall be harrowed and scarified, moistened or dried as required, and recompacted as specified under Section 5.2, so that a tight bond will be obtained with the next layer to be placed.

Section 5.7 Rollers. Compaction of all types of materials, insofar as practicable, shall be accomplished by rolling with a rubber-tired roller. The roller shall be drawn by an approved track-type power unit having ample tread areas. The rate of travel shall not exceed 2-1/2 miles per hour except as may be permitted by the Engineer.

The rubber-tired roller shall have a maximum gross weight of at least 40 tons and a weight without ballast of not more than 16 tons. The tires and tire pressure shall be such that the tread in contact with the surface will flatten slightly as the tire rolls, but not such that the side walls flex. At maximum gross load the tire pressure that will provide the above flattening shall be not less than 75 psi. The width of tire tread shall be not less than 65 percent of the center-to-center spacing of the tires. Tires shall be maintained such that the grooves in the tread are at least 3/8 in. deep. The loading of the roller and the tire pressure shall be varied as directed after experience is gained in the compaction of the various materials available for the embankment.

Section 5.8 Compaction. After each embankment layer has been spread to the required thickness and its moisture content has been adjusted as necessary, it shall be rolled as specified. Not less than four passes of a tire of the rubber-tired roller will be required on every portion of each layer of embankment. In order to perform this operation to best advantage on the impervious and pervious embankment, the moisture content of the layer being rolled and the one next below it, must be very near the optimum. In case embankment of any class sinks and weaves under the roller or under hauling units and other equipment, it will be evident that the required degree of compaction is not being obtained and that an adjustment in the moisture content is required. If at any place or time such sinking and weaving produces surface cracks which are of such character, amount, or extent as in the judgment of the Engineer to indicate an unfavorable condition, he will order operations on that part of the embankment to be suspended until such time as it shall have become sufficiently stabilized. The ideal condition of the embankment is that attained when the entire embankment below the surface being rolled is so firm and hard as to show only the slightest weaving and deflection as the roller passes. In order to minimize the condition of sinking and weaving the Contractor shall at all times keep the rolling operations spread out over the maximum practicable area. Adjacent roller trips shall overlap each other sufficiently to ensure uniform compaction.

If the moisture content is less than that most favorable for compaction, the rolling shall not proceed except with the specific approval of the Engineer, and in that event, additional rolling shall be done, as directed by the Engineer, to obtain the required compaction, and no adjustment in price will be made therefor. If the moisture content is greater than that most favorable for compaction, material of such water content may be removed and stockpiled for later use or the rolling shall be delayed until such time as the material has dried until it contains only the most

favorable moisture content, and no adjustment in price will be made on account of any operation of the Contractor in removing and stockpiling, or in drying the materials or on account of delays occasioned thereby.

If, because of insufficient overlap, too much or too little water, or other cause attributable to defective work, the compaction obtained over any area is less than that required, the condition shall be remedied, and if additional rollings are ordered, payment will not be made therefor as hereinafter specified. If the material itself is unsatisfactory or if additional rolling or other means fails to produce satisfactory results, the area in question shall be removed down to material of satisfactory density and the removal, replacement, and rerolling shall be done by the Contractor, without additional compensation.

Compaction by approved, hand-operated, power-driven tampers, weighing not less than 100 lb., or other approved equipment, will be required to a point 2 ft. above the 36-in. pipe, and on backfill of embankment adjacent to the gatehouse, spillway walls, rough rock surfaces, and steep or irregular abutment contacts, where compaction by means of the roller specified for use on the dam embankment is impracticable or undesirable.

Material to be so compacted shall have the best practicable moisture content for compaction and shall be spread in layers not more than 3 in. thick, and the degree of compaction obtained by these tamping operations shall be equal in every respect to that secured by the rolling operation in adjacent areas.

Compacted embankment that may be damaged by washing or otherwise shall be acceptably replaced by the Contractor without additional compensation therefor.

Section 5.9 Additional Rolling. In case it should become necessary, in order to obtain the required degree of compaction, to do more rolling on any or all of the embankment layers than the specified four passes of a rubber-tired roller, the Contractor shall do such additional rolling as the Engineer may order. Such additional rolling shall be paid for under Item 5e, as hereinafter provided. The number of roller trips shall be computed without regard to necessary overlaps or to rolling down in turning the equipment at the ends of the lanes or to such rolling parallel to the abutments as may be needed to secure the required degree of compaction in the embankment as close as possible to the junction between it and the abutments.

Section 5.10 Miscellaneous and Random Fills. Random fill or other miscellaneous fills shall be of suitable materials and built up in successive layers until it has reached the required elevation.

Placing and spreading, moisture content and control, rollers, and compaction shall be as hereinbefore prescribed for the dam except that material shall be placed in layers not exceeding 24 in.

in thickness before compaction; all stones having a maximum dimension greater than 18 in. shall be removed; and compaction shall be equal to 90 percent of that obtainable with the specified equipment and number of passes.

Section 5.11 Allowance for Shrinkage. The embankments shall be built to a height above the finished grade which will, in the opinion of the Engineer, allow for the shrinkage of the material. If any of the embankment or refilling settles so as to be below the required level for the proposed finished surface at any place before the final acceptance of the work, the Contractor shall at his own cost and expense supply approved materials and build up the low places as directed. An initial excess of at least one percent of the total height of the embankment, measuring from the stripped surface to the top of the finished embankment, shall be provided at all points. The cost of placing this excess material and subsequently regrading it, shall be covered under the appropriate items for earth embankment, one payment only being made.

Section 5.12 Borrowpits. Additional material needed for embankments, particularly impervious material, shall be obtained from one or more borrowpits located on land of the Owner taken for the Putnamville Reservoir. It is proposed to obtain most of the impervious material from Borrow Area No. 1, as indicated on the drawings, with additional increments from Borrow Areas No. 7 and 9. Preliminary explorations indicate that Borrow Area No. 5 may be a source of pervious material. However, the amount of suitable material available is not known. If suitable pervious material is not available in adequate quantities, the Contractor will be required to furnish pervious material from private sources under Item 5d. This shall not be done until all reasonable exploration and efforts have been made on lands of the Owner, within the Putnamville Reservoir site to find and excavate suitable pervious material.

Item 5d includes locating and exploring proposed borrow areas outside of lands of the Owner within the Putnamville Reservoir site, purchase of the material, clearing, stripping, cleaning up of the area, and hauling the material to the site of the work.

Prior to the excavation of borrow material, borrowpits shall be thoroughly stripped of all soil containing organic or other deleterious material as the Engineer may direct. The extent and depth of all excavations to be made in borrow areas shall be as approved by the Engineer.

After completion of the work, all borrowpits on lands of the Owner shall be graded and sloped as required, so as to avoid leaving undrained areas, and all unsightly piles of rock, isolated boulders, and other debris shall be removed or covered. All borrowpits shall be left in an acceptable condition at the completion of work under this contract.

METCALF & EDDY
ENGINEERS
INTER-OFFICE CORRESPONDENCE

400 Locust St.,
Denvers, Mass.
June 15, 1954.

Salem Rev.-Putnamville C.E.J.

Weekly Report, Contract 1, Week ending June 12, 1954.

Contractor's operations.

East Dike. A bulldozer and dragline stripped and removed the remainder of the mud lying on the stripped surface on the upstream side of the Dike, sta. 4+50 to 6+75.

Impervious embankment was placed on the central portion of the Dike, sta. 4+50 to 9+00 to approx. elev. 55, and on the upstream side of the Dike, same stations, to approx. elev. 52. Compaction was made with the sheepsfoot roller during the early part of the week and with the rubber tired roller during the latter part of the week. Impervious material from Borrow Area 1 was excavated and placed in with the 3 Euclid scrapers.

Laborers partially constructed the stone fill, stas. 5+00 to 6+50. Stone was picked up from stone walls in the vicinity and from stockpiles of blasted ledge from Locust St. Drain.

Sand and washed stone downstream filter was constructed, stas. 4+50 to 9+25.

West Dike. The remainder of the cutoff trench, stas. 0+00 to 3+08 was backfilled with impervious material from Borrow Area 9-100. Considerable seepage from both banks was encountered, as the backfill was placed, causing the banks to slough continuously. Between stas. 1+50 and 3+00 the cutoff trench at the top was 50ft. to 60 ft. wide. Throughout the week a clamshell removed mud from the trench as it was stripped and bulldozed ahead. As the trench was too wide to work the full width at once, the problem was overcome by stripping the mud and backfilling the downstream half of the trench to prevent further sloughing of the west bank, and then stripping the mud and backfilling the upstream half of the trench.

The sand and washed stone downstream filter was completed, sta. 3+00 to the north end at 6+25. Sand came from Vitale's pit and stone from Georgetown Sand & Stone Co.

The stone fill at the downstream toe was constructed, stas. 3+00 to 5+40. Pervious embankment was then placed over the downstream filter between these stations. A few loads were excavated from Connor's pit, but after inspection of the material at the Dike, and in the banks at the pit, the pit was abandoned as a source of pervious material because of excess fines. For the remainder of the week,

Salem Rev.-Putnamville.

Weekly Report, con't.,Contract 1, week ending June 12, 1954.

pervious material came from the Georgetown Sand & Gravel Co. pit.

Between 3/00 and 6/00 pervious and impervious embankment adjacent to the downstream toe were placed concurrently in order to bring the downstream side up to the elevation of the fill in the central portion of the Dike. Compaction of impervious embankment in the cutoff trench was made with the sheepsfoot roller, and embankment above the cutoff trench was compacted with the rubber tired roller.

Spillway. An approx. 2 in. thick wearing surface was placed in the section of the stilling basin concrete slab at sta. 2/39 to 3/13. Previously the slab had been covered with wet quilts for approx. a week. Before placing the concrete finish course, the old surface was cleaned and the surface dried with an air compressor. A slurry of 1 part Embeco cement and 2 parts portland cement by volume was then brushed over the surface. Following this, the finish course of a 1:1:1 mix of cement, sand, and peastone was placed. After finishing,the slab was covered with quilts and wet down for curing.

Locust St. Drain. Fill and loam were hauled to Johnson's and Choate's property and were spread with the grader.

Laborers excavated the ditch at 0/00 to 2/50 with hand tools.

Miscellaneous. A pit in Hamilton operated by McCarthy Bros. of Peabody was inspected, tested, and approved for pervious material from outside sources.

A pit in Hamilton operated by McIsaac of the North Shore Sand and Stone Co. was tentatively approved providing that after the pit is stripped and cleaned, it will again be inspected and tested for final approval.

The Contractor has made arrangements to rent a second rubber tired roller from the Contractor at the Groton Conn. job for the next few weeks until it is needed at Groton. It is due here in a week or so.

An electrician strung wire and flood lights on trees along the East Dike preparatory to working a second 8 hr. shift. Before starting a night shift, the lights will be inspected after dark to see if there is satisfactory lighting at the Dike and in the pit.

METCALF & EDDY
ENGINEERS
INTER-OFFICE CORRESPONDENCE
(3)

Salem Rev.-Putnamville

Weekly Report, Contract 1, week ending June 12, 1954.

Soils Lab Report.

12 tests for field unit wt. were made on impervious embankment at the East Dike. Dry field unit wt. varied from 122 to 148 lb./ c.f. which is 92% to 111 % of lab. optimum unit wt. Two of the tests gave compaction results under the spec. minimum of 97 % of lab. optim., requiring additional compaction. Average of all 12 tests was 134 lb/c.f. which is 101% of lab. optimum.

12 tests for field unit wt. were made on impervious embankment at the West Dike. Dry field unit wt. varied from 123 to 151 lb./c.f. which is 96% to 117% of lab. optimum unit wt. Average of the 12 tests was 136 lb. /cu. ft/, which is 105% of lab. optimum.

Four horiz. cap.tests were made on impervious samples from the East Dike. k varied from .013 to .095 x 10^{-4} cm / sec.

9 horiz.,cap. tests were made on impervious samples from the West Dike. k varied from .051 to .208. This shows an improvement over material coming from Borrow Area 9-100 in previous weeks. Previous samples had run as high as k = .5.

Moisture content at both Dikes averaged approx. 1.5% above optimum moisture content.

Further examination and tests of material from Connor's pit after the pit was stripped and cleaned showed that the pit is unsatisfactory as a source of pervious material.

Horiz. cap. and constant head permeameter tests of material from Mc Carthy's pit in Hamilton gave satisfactory results. Two pits, Georgetown Sand & Gravel Co, and McCarthy's pit are now satisfactory sources. However, the Contractor is still searching for cheaper sources of satisfactory pervious material.

IJ. Rosenfield
IJ. Rosenfield

Encl: 8 sheets Soils Lab. Report.

METCALF & EDDY

ENGINEERS

INTER-OFFICE CORRESPONDENCE

FILE ...SUB...

400 Locust St.,
Danvers, Mass.
September 13, 1954.

Salem Rev.-Putnamville

Weekly Report, Contract 1, week ending September 11, 1954.

Contractor's operations.

Dam. Pervious embankment was placed south of the spillway, Sta. 1+00 to 4+72, bringing the pervious zone up to elev. 70. Pervious material came from the Travers' pit in Rowley.

Impervious embankment was placed south of the spillway, sta. 0+00 to 4+72.

At Sta. -(0+05) to 0+37, a deep pocket in the ledge was excavated for the cutoff trench down to clean ledge or to impervious earth bottom of trench. Impervious material was compacted with the Barco tamper against the vertical rock surface. When the bottom was shaped up so as to provide access with the rubber tired roller, the latter was used.

Adjacent to the south spillway wall the Barco tamper was used to compact impervious embankment. Trenches for spillway wall footings were cleaned and backfilled with impervious material, compacting with the Barco.

A bulldozer shaped up the upstream slope, dozing excess material up the slope to the top of embankment, where it was spread and rolled.

Loam At the end of the week, embankment south of the spillway varied from subgrade at sta. 0+00 to within 1.5 ft. of subgrade at the spillway wall.

East Dike. A bulldozer shaped up the upstream slope of the dike, Sta. 15+00 to 17+00 and 2+00 to 3+00, dozing the material to the top of embankment where it was spread and rolled.

Surface of embankment at the East Dike, sta. 0+00 to 17+50, varies from subgrade to 2 ft. below subgrade.

Loam

West Dike. The truck crane cast loam over the downstream slope. Laborers spread and graded the loam over the slope.

Outlet Works. Carpenters completed erecting forms and miscellaneous metal work for the next stage of gatehouse walls and floor slab, elev. 71.08 to 76.0.

Locust St. Drain. 3½ cu. yds. Class A concrete were placed

Salem Rev.-Putnamville

Weekly Report, cont'd., Contract 1, week ending Sept. 11, 1954.

in the headwall for the 15 in. concrete pipe on the west side of Locust St., main branch.

Stripping Borrow Pit. Additional topsoil was stripped in Borrow Area 1.

Soils Lab. Report.

Tests which were incompleted last week due to power failure after the hurricane, are included in this week's lab. report. Results of tests reported in last weeks report are not duplicated this week.

8 tests for field unit wt. on impervious embankment at the Dam, compacted with the rubber tired roller, gave results varying from 130 to 143 lb. / cu. ft., which is 98% to 107% of lab. optimum unit wt. Average of the 8 tests was 137 lb./cu.ft. which is approx. 102% of lab. optimum.

Three tests for field unit wt. on impervious embankment at the Dam, compacted with the Barco mechanical tamper, gave results varying from 129 to 138 lb./cu.ft., which is 97% to 103% of lab. opt. Average of the 3 tests was 134 lb./cu.ft. which is approx. 100% of lab. optimum.

Three tests for field unit wt. on pervious embankment at the Dam, compacted with the rubber tired roller, gave results varying from 133 to 141 lb. / culft., which represent relative densities ranging from 90% to 100%.

5 horiz. cap. tests for permeability made on impervious embankment at the Dam gave coeficients of permeability ranging from .021 to .040 x 10^{-4} cm/sec/

Three horiz cap. tests on pervious embankment at the Dam, originating from Traver's pit in Rawley, gave coeficients of permeability k ranging from 9.2 to 17.3 x 10^{-4} cm/sec.

DJ Rosenfield

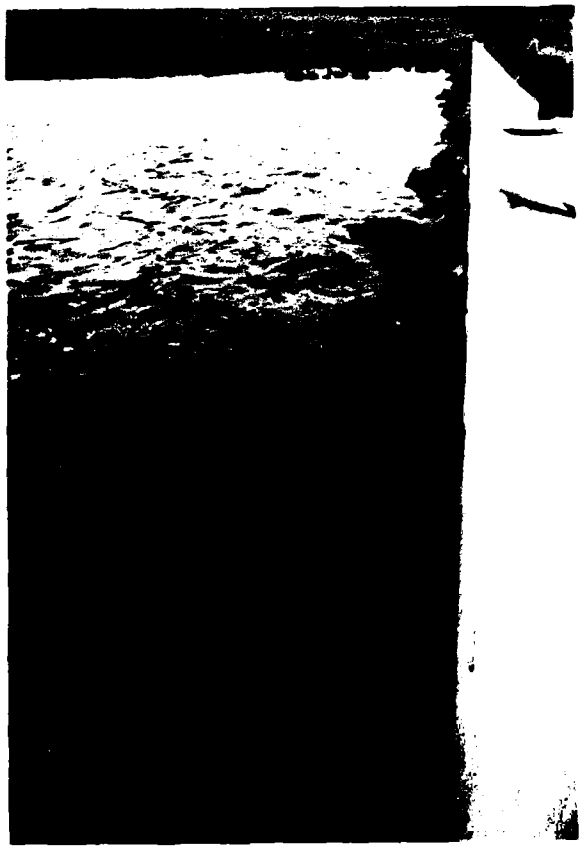
Encl: 2 sheets Soils Lab. Report.

APPENDIX C

PHOTOGRAPHS

(For locations of photographs, see Figures B-1A, B-4A, and B-5A in Appendix B)

NO. 1 DAM – UPSTREAM FACE LOOKING FROM NORTH ABUTMENT

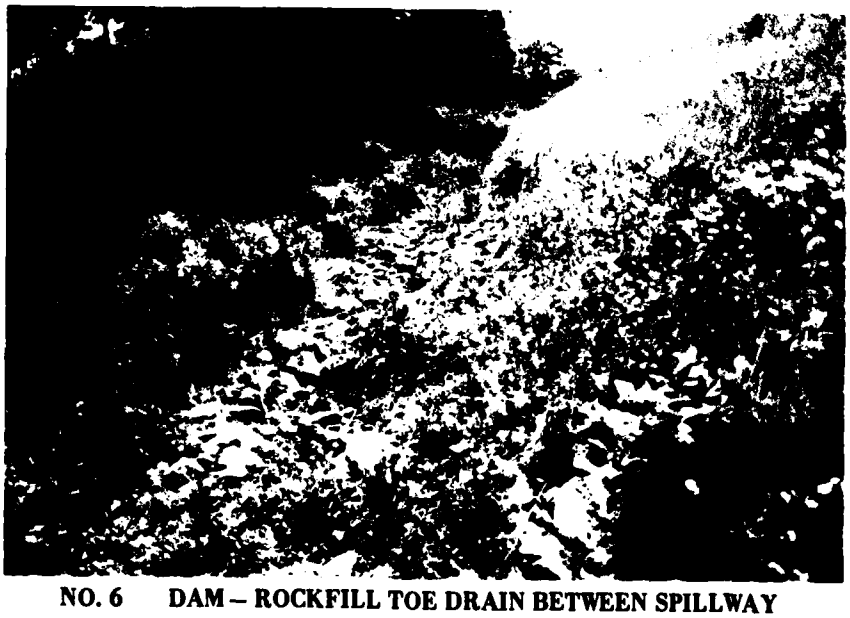


NO. 2 DAM – TYPICAL RIPRAP ON UPSTREAM FACE

NO. 3 DAM – TOP OF EMBANKMENT AND UPPER DOWNSTREAM SLOPE LOOKING FROM NORTH ABUTMENT

NO. 4 DAM – BENCH COVERED WITH ROCK FILL AND LOWER DOWNSTREAM SLOPE

NO. 5 DAM – EMBANKMENT BETWEEN SPILLWAY AND SOUTH ABUTMENT

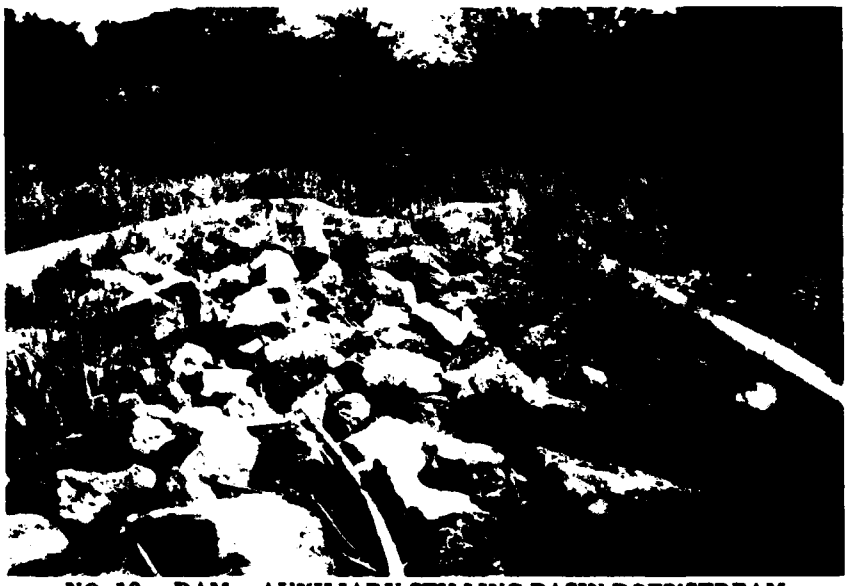


NO. 6 DAM – ROCKFILL TOE DRAIN BETWEEN SPILLWAY AND SOUTH ABUTMENT

NO. 7 DAM – SPILLWAY WEIR AND UPPER PORTION OF DISCHARGE CHANNEL

NO. 8 DAM – LOWER PORTION OF SPILLWAY DISCHARGE CHANNEL

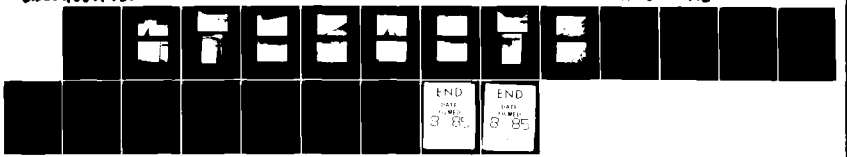
NO. 9 DAM – STILLING BASIN AT END OF SPILLWAY DISCHARGE CHANNEL

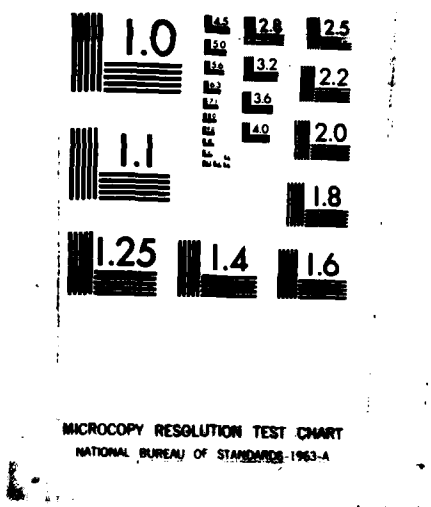


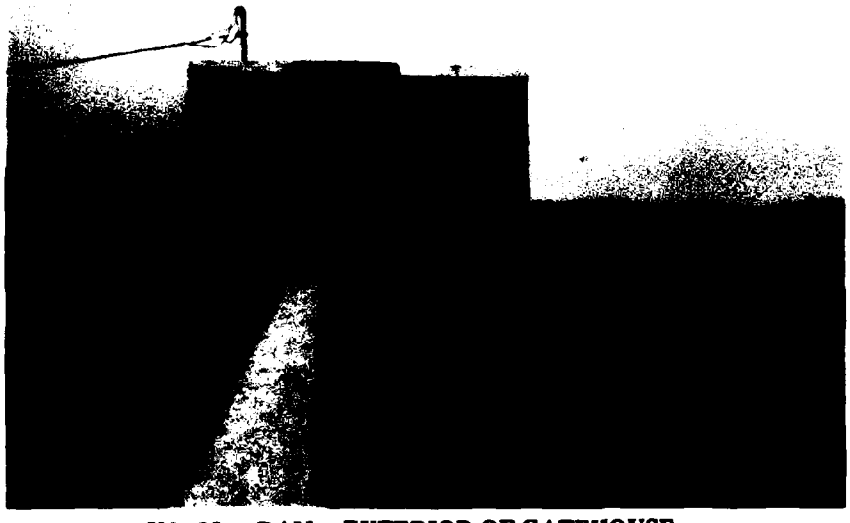
NO. 10 DAM – AUXILIARY STILLING BASIN DOWNSTREAM OF SPILLWAY DISCHARGE CHANNEL

AD-A165 703 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS PUTNAMVILLE RESERVOIR.. (U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV AUG 80 2/2

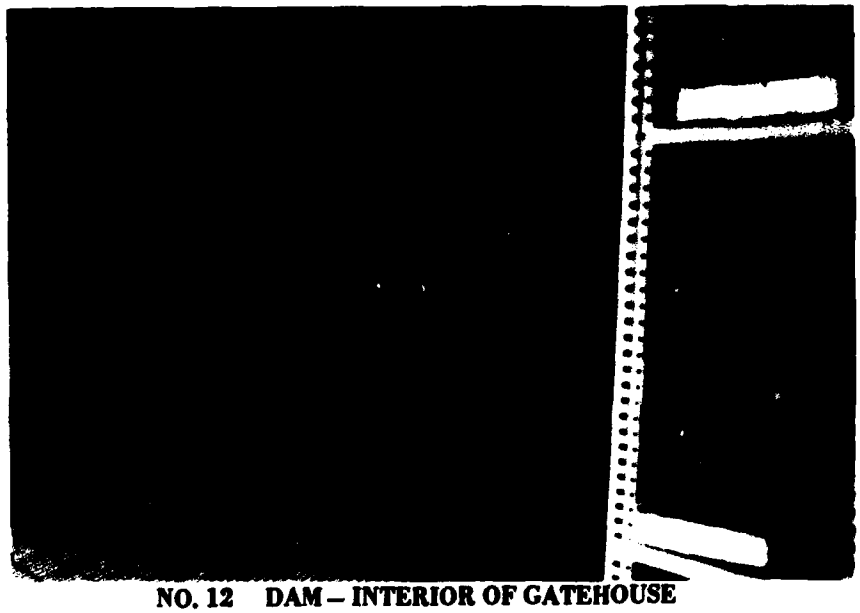
UNCLASSIFIED F/G 13/13 NL



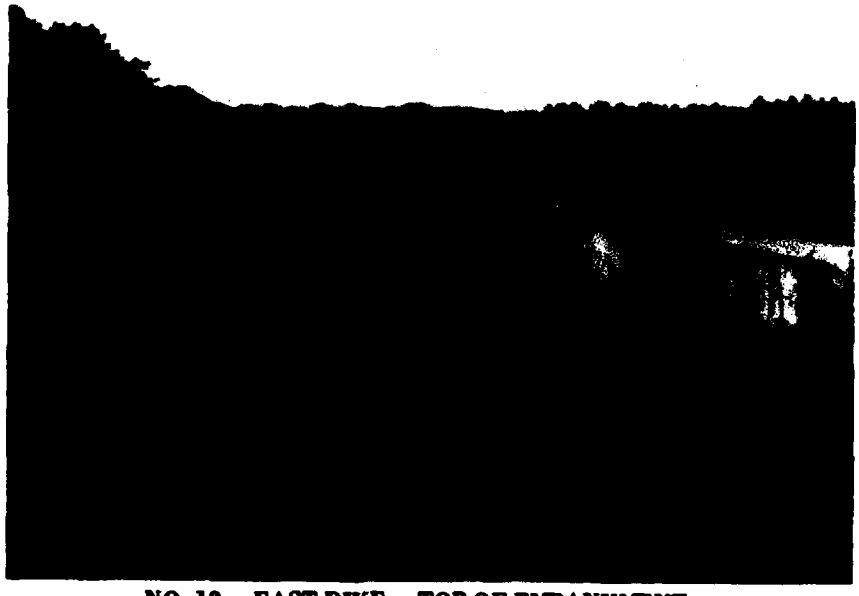

1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



NO. 11 DAM – EXTERIOR OF GATEHOUSE



NO. 12 DAM – INTERIOR OF GATEHOUSE



NO. 13 EAST DIKE – TOP OF EMBANKMENT

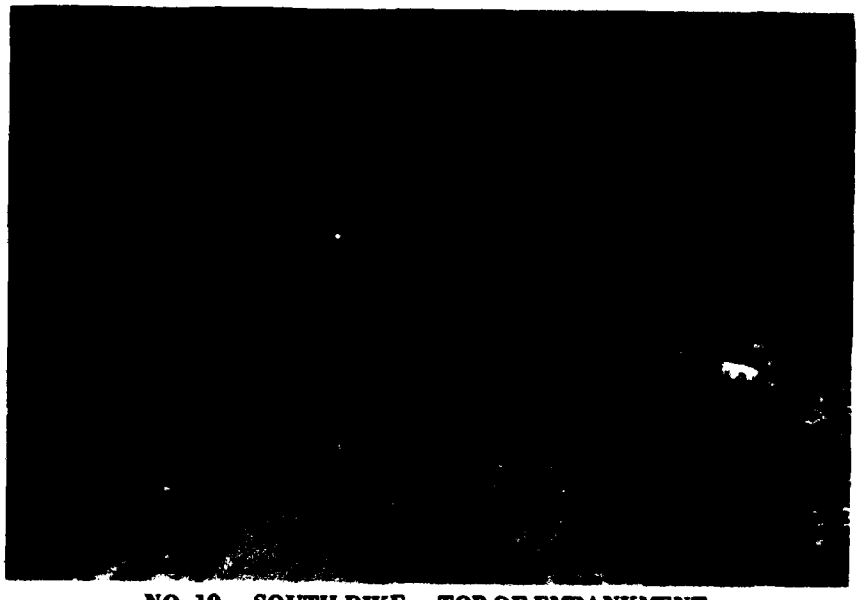
NO. 14 EAST DIKE – UPSTREAM FACE NEAR BEND IN EMBANKMENT WHERE RIPRAP IS MISSING

NO. 15 EAST DIKE – DOWNSTREAM SLOPE NEAR NORTH ABUTMENT

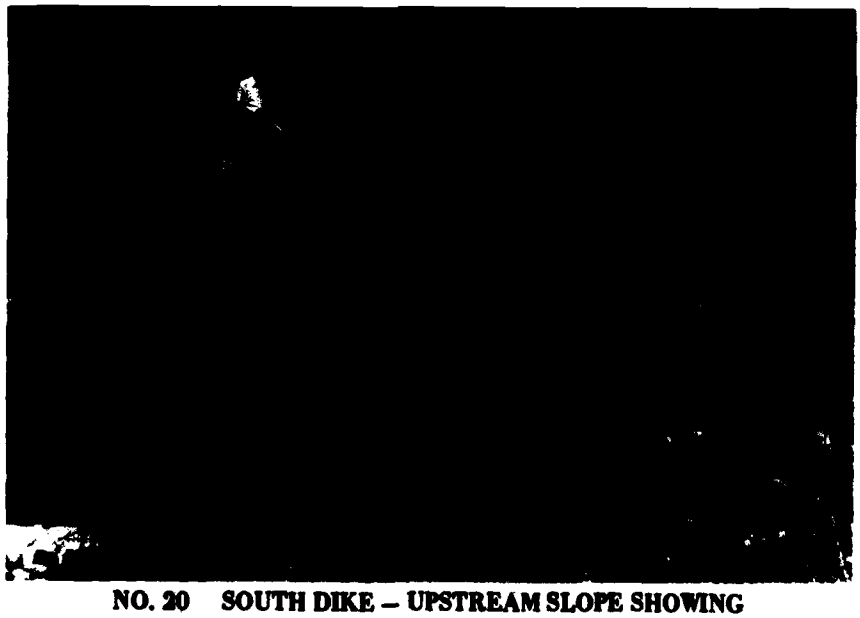
NO. 16 EAST DIKE – DOWNSTREAM SLOPE NEAR BEND IN EMBANKMENT

NO. 17 EAST DIKE – AREA OF CATTAILS AND SEEPAGE DOWNSTREAM OF BEND IN EMBANKMENT

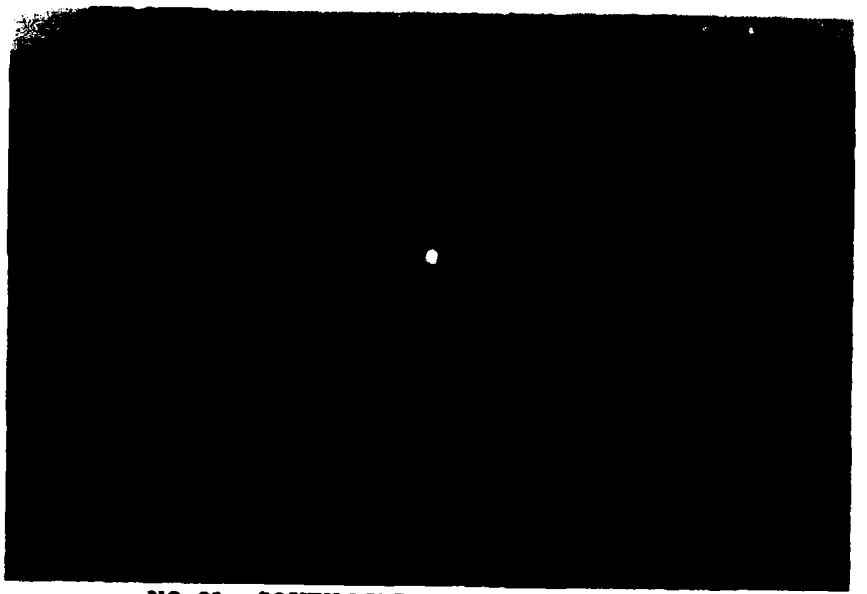
NO. 18 EAST DIKE – STANDING WATER ALONG LOCUST STREET NEAR NORTH ABUTMENT



NO. 19 SOUTH DIKE – TOP OF EMBANKMENT

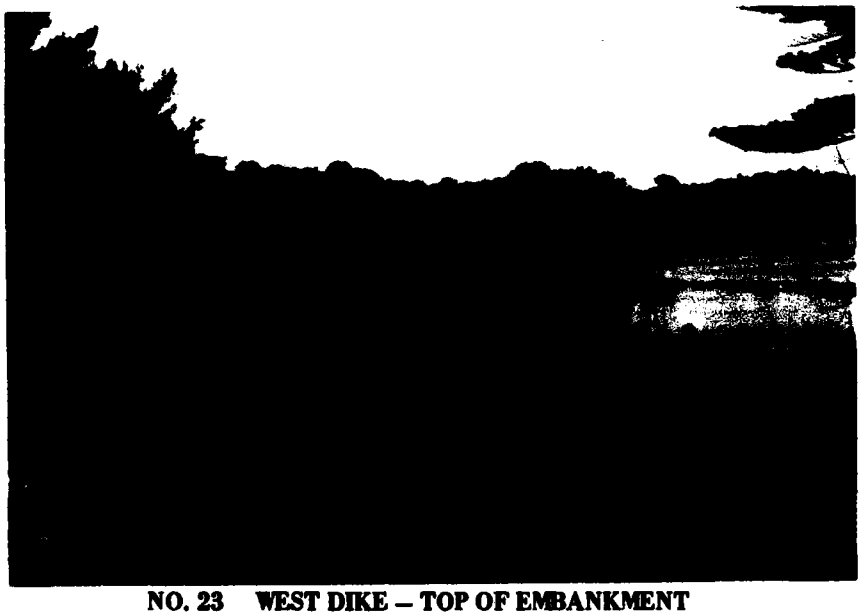


NO. 20 SOUTH DIKE – UPSTREAM SLOPE SHOWING UNDERSIZED RIPRAP IN FOREGROUND

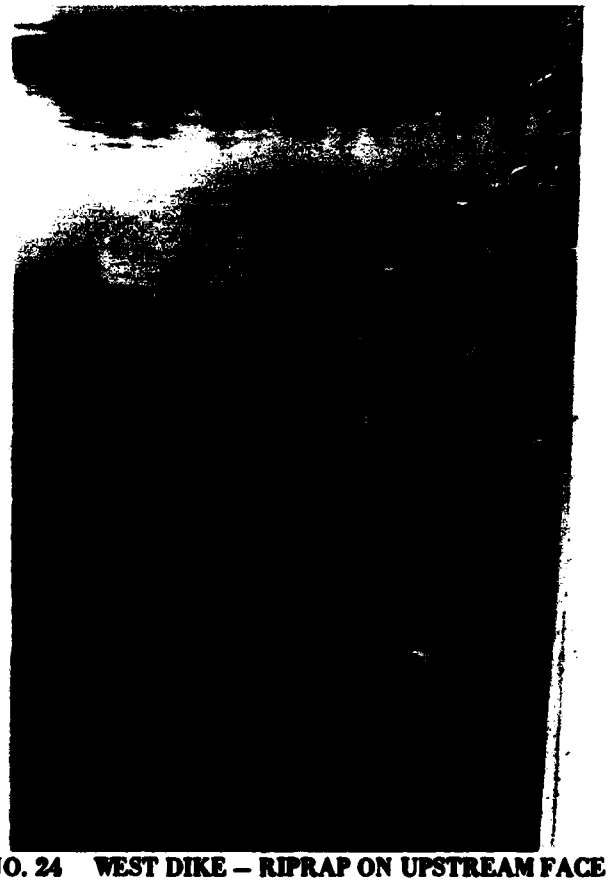


NO. 21 SOUTH DIKE – DOWNSTREAM SLOPE

NO. 22 SOUTH DIKE – ROCKFILL DRAIN AT DOWNSTREAM TOE



NO. 23 WEST DIKE – TOP OF EMBANKMENT



NO. 24 WEST DIKE – RIPRAP ON UPSTREAM FACE

NO. 25 WEST DIKE – DOWNSTREAM SLOPE AND OVERGROWN ROCKFILL TOE DRAIN

NO. 26 WEST DIKE – TYPICAL SEEPAGE AREA AT DOWNSTREAM TOE

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

Project Nat. Review of Non Fed. Dams Acct. No. 7252 Page 1 of 8
Subject Essex County, Mass. Compld. By LEE Date June 15, 1981
Detail PUTNAMVILLE RESERVOIR Ck'd. By PAC Date 7-28-81

(I) Test Flood, Storage & Storage Function

1- Total Drainage Area - 0.85 mi²

2- Pond(s) Area: 0
Swamp(s) Area: 0
Total Area Pond(s) & Swamp(s):

% Ponds & Swamps = —— = 0%

3- $\frac{223-74}{3800} = .0392$ } Say Ave Slope = 4%

4- Using C. of E. Curves for Peak Flow Rates & above guide values the Peak Flow Rate was estimated to be 2850 c.f.s./mi²

Size Class: Intermediate; Hazard Pot.: High; Spill. Des. Flood: Full PMF
Use: Test Flood = FULL PMF

5- Test Flood Inflow = (2850) 0.85 = 2420 c.f.s. *

* Add 40cfs from Canal Pump. Sta for total peak inflow in Storage Funct. Also see note on Page 2

6- Pond Storage
The pond area is 0.45 sq. mi. at elev. 74.0. Based on a const. area, storage increases at 290 ac. feet per foot of depth increase.

7- Spillway crest elev. is 79.8

8- Storage Functions are based on $Q_{out} = Q_{in}\left[1 - \frac{S_{out}}{R}\right]$

S_{out} = Storage Vol. in Reservoir related to final Q_{out} in terms of inches of rain over the drainage area.

S(in Inches) $= 12\,D\left(\frac{0.45}{0.85}\right) = 6.35\,D$; R = 6hr rain of Storm

D = Storage depth in feet above spillway crest in reservoir

9- Storage Functions: (Test Flood & ½ PMF - if needed)

$F_{TF} = 2460 - 127.4\,S = 2460 - 809\,D$
$F_{\frac{1}{2}PMF} = 1250 - 127.4\,S = 1250 - 809\,D$

(II) Discharge Relations

A- Spillway

30' wide ogee crest ; $Q_A = 4.0(30) H_A^{1.5} = 120 H_A^{1.5}$
Suppressed side contractions ; Crest el. 79.8

H_A	0.5	1.0	1.5	2.0	2.5	3.0	1/12 = .083' *	4.0
Q_A	40	120	220	340	470	620	2.89 cfs *	960
El.	80.3	80.8	81.3	81.8	82.3	82.8	79.883 *	83.8

* Max. reported hd on crest is 1 inch. Wind effects could prod. greater disch.

(III) Low Level Outlet

Res. lowered by disch. to Wenham Lake, in ± 13,000 feet long, 36" ϕ conc. lined conduit. Assume minor losses are insignif. rel. to frict. loss. Assume n = 0.13

Putnamville Res. @ el. 79.8
Wenham Lake @ el. 32.0
47.8 max. disch. head

$Q_1 = 7.07 \frac{1.49}{.013} (.75)^{2/3} \left(\frac{47.8}{13000}\right)^{1/2} = 668.9 (.00368)^{1/2} = 40.6$ cfs

$Q_2 = 668.9 \left(\frac{46.8}{13000}\right)^{1/2} = 40.1$ cfs ; $\frac{Q_1 + Q_2}{2} = 40.35$ cfs.

Top 1 ft contains 290 ac.ft

Time to Lower Res. 1 ft. = $\frac{290 (43560)}{40.35} = 0.313 \times 10^6$ sec = 87 hours

---

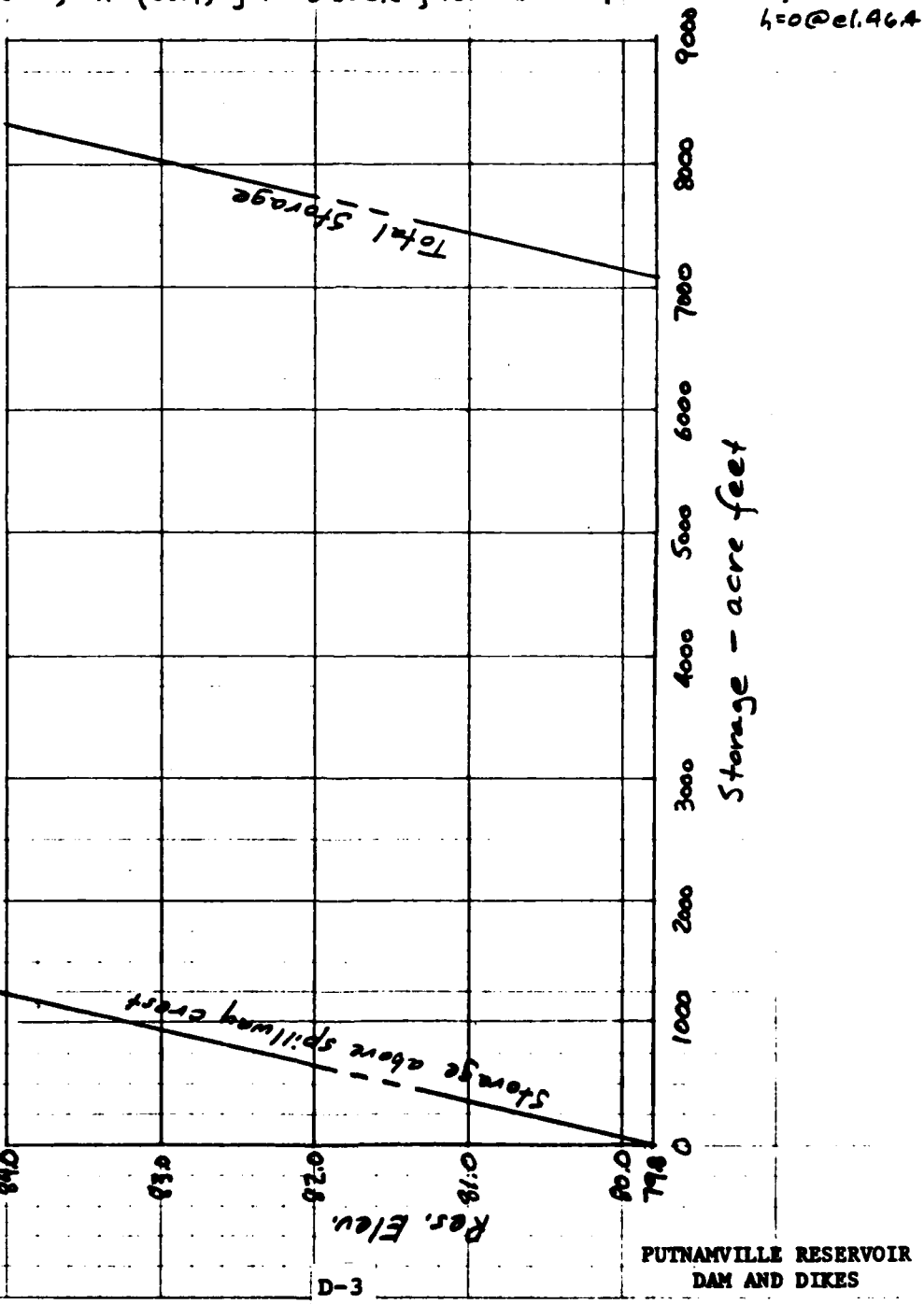
Note: Since the reservoir occupies over half of the drainage area, the full PMF inflow to the reservoir may be higher than 2420 cfs.

Adding the total PMP of 19" over 0.85 sq. mi. to a reservoir of 0.45 sq. mi., raises the level by 35.9 in. or 2.99 feet, if there was no spillway discharge. The resulting peak water level is at elev. 82.8, which is a foot below the dam crest.

Project Nat. Review of Non Fed. Dams Acct. No. 7252 Page 3 of 8
Subject Essex County, Mass. Comptd. By LEB Date 7/14/81
Detail PUTNAMVILLE RESERVOIR Ck'd. By DAC Date 7/29/81

(IV) Reservoir Storage

Assume area const. at 290 ac. above el 79.8. Based on owners data, storage vol. is 7100 ac. ft. with res. at el. 79.8
Bel. spill., Vol. = $7100(43560) = K'hA$; $A \propto h^2$; $A = 11324h^2$; $Vol. = K''h^3$;
$7100(43560) = K''(83.4)^3$; $K'' = 8300.5$; For Vol. in Ac. ft, $K''' = 0.1906$; $V = K'''h^3$
h=0 @ el. 46.4



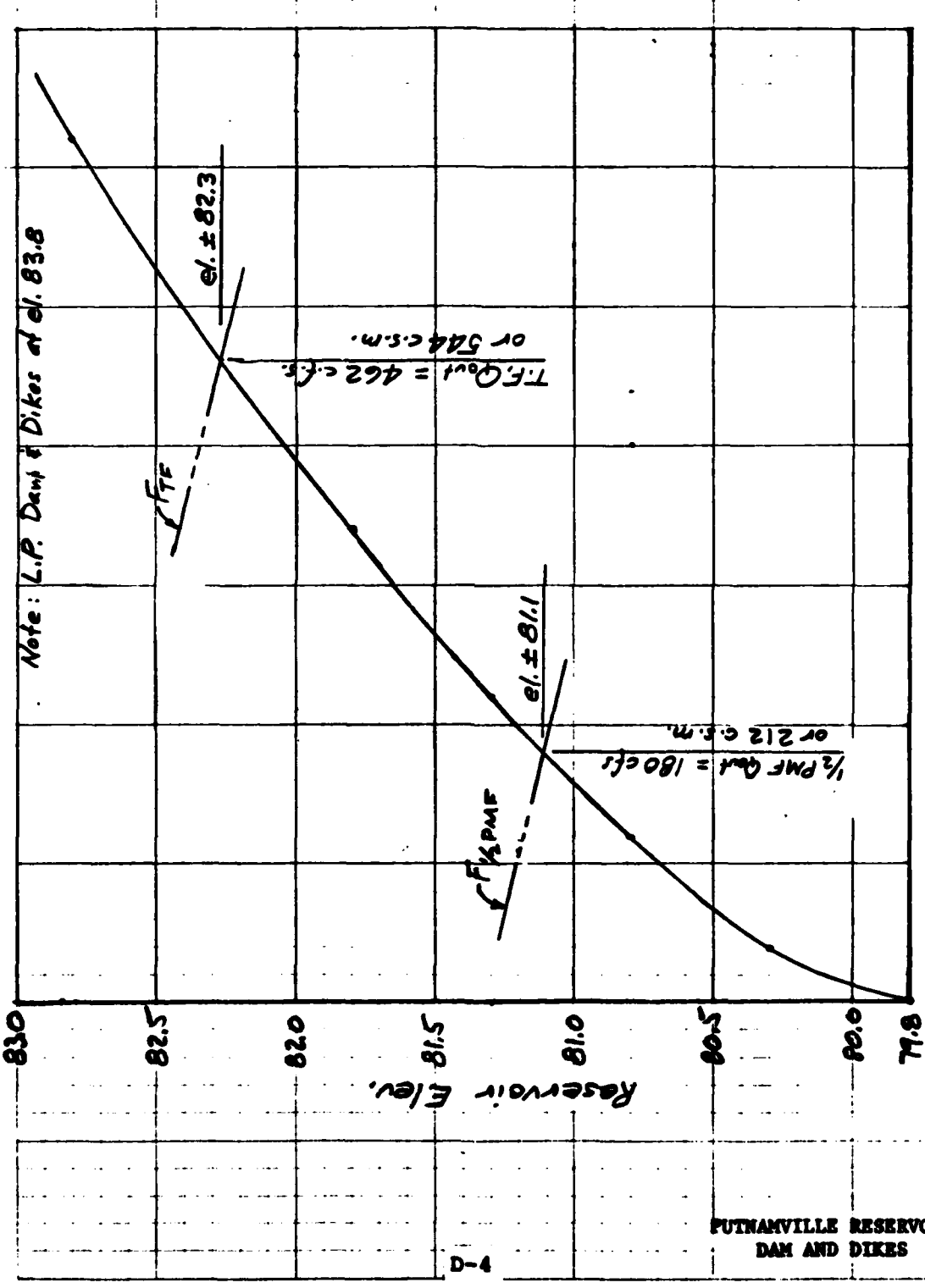
PUTNAMVILLE RESERVOIR
DAM AND DIKES

Project Nat. Review of Non-Fed. Dams Acct. No. 7252 Page 4 of 8

Subject Essex County, Mass. Compt'd. By LEB Date 7/14/81

Detail PUTNAMVILLE RESERVOIR Ck'd. By DAC Date 7/28/81

(V) Discharge & Storage Function vs. Reservoir Elevation



METCALF & EDDY, ENGINEERS

NONREPRODUCIBLE GRID FORM 143

PUTNAMVILLE RESERVOIR
DAM AND DIKES

(VI) Failure of Dam - Main Dam

Peak Failure Flow:

Pond Elevation - 82.3 (Max. T.S. el.)
Toe Elevation — 46.4
Y_o = 35.9 feet

Dam Length Subject to Breaching = 650 ft (main section north of spill.)
$W_o = 40\%(650) = 260$

$$Q_{P_1} = 1.68\, W_o (Y_o)^{1.5} = 1.68(260)(35.9)^{1.5} = 93{,}955 \text{ cfs}^*$$

Continuing Spill. Disch.: 462 cfs
Peak Failure Flow: Say - 94,000 cfs

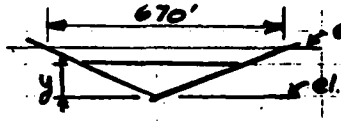
*see adj. Q_{P_1} below

Storage Volume Released:

Storage Above Spillway 700 ac. ft.
Storage Below Spillway 7100
Total Storage 7800 ac. ft.

Channel Hydraulics:

Assume critical depth at 1st downstr. restriction at ± Locust St.



$A = 29.65\, y^2$; $B = 59.3\, y$

$$Q_c^2 = g\left(\frac{A^3}{B}\right) = 32.2\frac{(29.65)^3 y^6}{59.3\, y}\,; \quad Q_c = 114.8\, y^{2.5}$$

Assume failure flow relates to Y_o', where $Y_o' = 82.3 - (48.7 + y)$

$$\therefore Q_{P_1} = 1.68(260)[33.6 - y]^{1.5} = Q_c = 114.8\, y^{2.5}$$

$$(33.6 - y)^{1.5} = 0.2628\, y^{2.5}$$

$$33.6 - y = (0.2628)^{2/3}\, y^{5/3} = 0.41\, y^{5/3}$$

y	10	15	11	12	11.1
$33.6 - y$	23.6	18.6	22.6	21.6	22.5
$0.41\, y^{5/3}$	19.0	37.4	22.3	25.8	22.6

$y \approx 11.1$

$Q_p \simeq 47000$ cfs
Adj. Peak Flow

Crit. el. = 48.7 + 11.1 = 59.8 ≃ el. 60

Just below failure water would rise to el. ±60, flooding 4 houses. Flow would continue on to Wenham Swamp, possibly affecting 8 more houses, then would continue to the Ipswich R. to ocean.

(VII) Peak Tailwater

The Full PMF produces a peak discharge of 462 c.f.s. The spillway discharges to a channel which eventually runs under Locust St, via a 2'x4' wide stone & conc. culvert. This flow greatly exceeds the culvert's capacity, when based on entrance control.

Assume all flow passes over Locust St. with only insignificant flow thru the culvert. The street is at el. 50.5 and has an effective width of about 400 ft.

$$Q_L = 2.67\,(400)\,H_L^{1.5} = 1068\,H_L^{1.5}$$

H_L	1.0	0.5	0.6	0.55	0.57
Elev	51.5	51.0	51.1	51.05	51.07
Q_L	1068	378	496	436	460

Tailwater would be at elev. ± 51.1 just before failure of the main dam shown on Sheet 5

(VIII) Failure of Dam - East Dike

Peak Failure Flow:

Pond Elevation - 82.3
Toe Elevation — 60.3
$Y_o = 22.0$

Dam Length Subject to Breaching = ± 750'
$W_o = 40\%(750) = 300'$

$$Q_{P_1} = 1.68\, W_o (Y_o)^{1.5} = 1.68(300)(22)^{1.5} = 52000^*$$

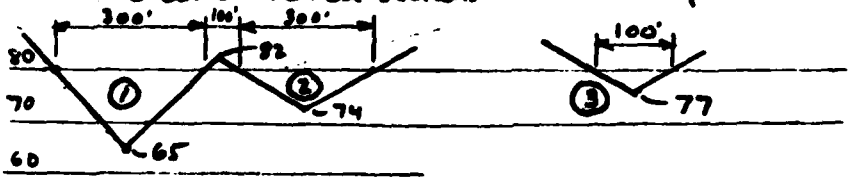
Continuing Spill. Disch.: (462 cfs, but in other area) *See Adj Peak below
Peak Failure Flow: (See below)

Storage Volume Released:

Storage Above Spillway 700 ac ft.
Storage Below Spillway $7100 - 0.190(13A)^3 =$ 6600
Total Storage 7300 ac. ft

Channel Hydraulics:

3 constricted sections can develop critical flow



2 N.E. sections 1 S.E. section

$B_1 = 20y_1$, $A_1 = 10y_1^2$; $B_2 = 50y_2$, $A_2 = 25y_2^2$; $B_3 = 33.3y_3$; $A_3 = 16.7y_3^2$

$Q^2 = g\left(\frac{A^3}{B}\right)$

Water el.	77	74	75	74.5
Q_1	20000	9800	12700	11200
Q_2	1600	—	100	—
Q_3	—	—	—	—
ΣQ	21600	9800	12800	11200
Adj Q_{P_1}	6200	12000	9900	11000

Adjusted Peak outflow is $Q_P = 11100$ cfs. Just below failure water level is el. ± 74.5' which would flood a number of houses

Project Nat. Review of Nonfed. Dams Acct. No. 1 & 2 Page — of —
Subject Essex County, Mass. Comput. By LED Date 7/14/81
Detail Putnamville Reservoir Ck'd. By DAC Date 7/28/81

(X) Failure of Dam - West Dike

Peak Failure Flow:

Pond Elevation - 823
Toe Elevation — 56.7
$Y_o = 25.6$

Dam Length Subject to Breaching = 480
$W_o = 40\%(480) = 192'$

$$Q_{P_1} = 1.68\, W_o (Y_o)^{1.5} = 1.68(192)(256)^{1.5} = 41800 \text{ cfs}^*$$

Continuing Spill. Ditch.: (462 cfs, in other area)
Peak Failure Flow: 41800 cfs*

*See below

Storage Volume Released:

Storage Above Spillway — 700 ac ft
Storage Below Spillway $7100 - .8776(10.2)^3 =$ 6900 " "
Total Storage 7600 " "

Channel Hydraulics:

Rte 1, at el. ± 60 for ± 800 ft will act as a weir: $Q_1 = 2.67\, h^{1.5}$ per ft., flooding swamp below dam & Bishop Meadow.

$Q_1 = 800(2.67)\, h_1^{1.5} = 2136\, h_1^{1.5}$

h_1	5	4	4.9
El.	65	64	64.9
Q_1	23900	17088	23200
Adj Q_{P_1}	23200	25300	24300

* Adj Q_{P_1} = 23200 cfs

Just below dam, water will flood to el. ± 65, flooding 3 houses and a gas. station.
Five ft. of water across Rte 1 will inundate trailer park (36 units) and other houses, before reaching Nichols Br. to the Ipswitch R.

Part "B" (continued)

HYDROLOGIC CONSIDERATIONS

Procedures for hydrologic design as contained in the latest edition of the U. S. Department of the Interior, Bureau of Reclamation "Design of Small Dams"

1. Peak Outflow *85.2 c.f.s.
2. Design storm duration 24 hrs. - 7.0 in rainfall.
3. Rainfall Intensity Maximum = 2.9 "/hr.
   Percent Runoff 44 % 3.1 inches.
4. Contributory Drainage Area **0.85 sq.mi. (550 acres)
   (attach a copy of U. S. Topographic Map with the outline of the drainage divide).
5. Previous Known flood of record
   (month) N/A (year) N/A (Pumped Storage Reservoir)
6. Design maximum flood level elevation 80.55.
7. Additional information:

* Includes effect of constant 38.7 cfs (25 mgd) inflow from Canal Pumping Station left on inadvertantly.. Peak storm reflow from tributary land area (290 acres) is 180 cfs.

** Includes reservoir water surface area of 0.40 sq. mi. (260 acres)

APPENDIX E

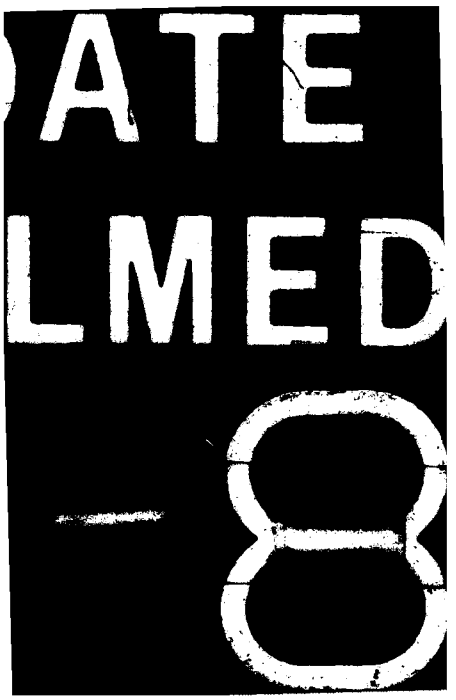
INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

PUTNAMVILLE RESERVOIR DAM AND DIKES

END

DATE
FILMED

8-85


ATE
LMED
8